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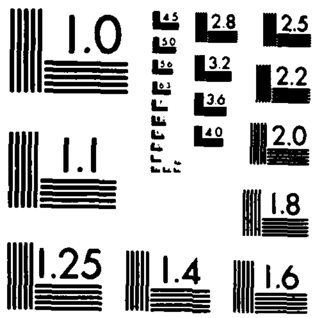

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Report No. CG-D-31-82

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SOLID PROPELLANT INFLATOR
FOR
PERSONAL FLOTATION DEVICES

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November 1981

FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
United States Coast Guard
Office of Research and Development
Washington, D.C. 20590

NOTICE

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Development, Test, and Delivery of Solid Propellant Generators for Inflation of PFD's	October 22, 1981
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16. Abstract

The objective of the program is to develop and test a solid propellant gas generation system as a practical replacement for CO_2 cartridges for inflatable life jackets and/or hybrid life jackets, with enhanced reliability and performance over a temperature range of -65°F to 185°F. To document comparative performance of the CO_2 and solid propellant systems, test beds of 20 lb. and 35 lb. buoyancy inflatables are employed. Repetitive tests are made of each system, over the indicated enviornmental span, with specimens subjected to shock, vibration, cycling, and many other tests necessary to prove functional and life savings reliability and capability. The solid propellant inflator (SPI) test results reflect uniform performance across the temperature range at time/pressure levels considered ideal for the usage. CO_2 cartridge performance was poor at soak temperatures below 20°F and above 150°F. As the SPI is pressured only upon activation, leakage during storage is not possible. Operating pressure is under 500 psi and a small over-pressure device negates the possibility of overpressure stress from a blocked orifice condition. It is concluded that the SPI represents a significant improvement in the inflation of life jackets and similar buoyant devices having the need for prompt, reliable, fail/safe performance. ISI recommends further development in areas of insulation, visual evidence of fired unit, and mating hardware in the life jacket.

17. Key Words	18. Distribution Statement
Solid propellant inflator (SPI) Reliability, Personal Flotation Devices Lifesaving Devices, Inflation Research	Document is available through the National Technical Information Service, Springfield, VA 22151

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PREFACE

The reported work draws on earlier development work performed by Inflation Systems International for the Naval Air Development Center (NADC), Warminster, PA, under contract N62269-79-C-0210.

The work for NADC was intended to produce a solid propellant gas generator inflator replacement for the conventional carbon dioxide gas inflator for the USN MK7 life raft. The NADC requirement was to design a replacement solid propellant gas generator having maximum dimensions of 4" X 29". The diameter constraint was approached with a T-burner design burning from cylinder center outward toward both ends. The length/diameter (L/D) ratio exceeded the limits for proper functioning and the raft (inflator) was not completely successful under that contract.

In working the problem, ISI developed a method of granulating the propellant to 12 mesh size. These granules, in turn, were lightly pressed into the generator chamber. The evolved approach produced low combustion pressure coupled with a readily tailored time-to-fill performance. This concept seemed ideally suited to the task of inflating life rafts and life jackets where reliability and operational safety are of primary importance, and where inflation time needs to vary by application.

Accordingly, ISI made an unsolicited proposal to the U.S. Coast Guard for application of the technique to small volumes such as personal flotation devices. The advantages of solid propellant inflator's non-leakage and uniformity of gas generation over a broad temperature range extending down into arctic temperatures, suggested important life saving missions for these inflators in recreational, commercial marine, and military operations. In this duty, the solid propellant approach could be demonstrated without constraint as to L/D ratio and in a small size representing the lower end of the spectrum of such devices. Ability to make a successful application for life jacket life volumes would show the wide application of the concept since very large volumes (to 400 cubic feet) had been demonstrated.

This report gives data on the successful demonstration of the solid propellant concept for personal flotation devices.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND SYMBOLS

AM	Actuating Mechanism
DVT	Design Verification Test
ISI	Inflation Systems International
SPI	Solid Propellant Inflator
PFD	Personal Flotation Device
20-lb Cartridge 35-lb Cartridge	A solid propellant gas generator with output providing sufficient gas volume to inflate an appliance providing 20 or 35 pounds buoyancy

1.0 INTRODUCTION.

1.1 Contract Reference. This final report summarizes the results of development work by Inflation Systems International under United States Coast Guard Contract DTCG23-80-C-20031 dated 25 September 1980.

1.2 Executive Summary. The reported effort is to demonstrate the suitability of a solid propellant inflator (SPI) as an inflation means for personal flotation devices. The SPI design has two sizes: 20 lb. and 35 lb. These sizes refer to the cartridge output which provides 20 pounds of buoyancy in a smaller size and 35 pounds of buoyancy in a larger configuration. The internal detail of design and construction are the same for each, except for the size and quantity of pyrotechnic material.

The SPI provides an improved performance for personal flotation devices (life saving appliances such as life jackets, vests and belts, intended to aid individual persons). The existing stored gas (carbon dioxide) gas cylinders function sluggishly at low temperature and do not provide the rapid inflation needed to assure survival of users. They are also susceptible to undetected leakage under the high pressures of liquid-state storage.

The reported work developed a small solid propellant inflator with a cool output not damaging to the personal flotation device (PFD) or the person using it. The SPI provides rapid, reliable inflation of PFD's at all temperatures of probable use including, particularly, arctic regions. The SPI design is approximately the same size as existing carbon dioxide units, is simple in construction, and reliable over long-term storage. It has the same simplicity in operation as the existing CO_2 system.

The SPI design consists of a separable gas generator cartridge of cylindrical shape and an actuating mechanism (AM) providing a lanyard-pull force to cock and fire a spring-loaded firing pin which strikes a percussion primer in the cartridge, igniting the pyrotechnic train. The same AM is used for both size cartridges. Assembly is by screw thread. A port identical to existing PFD inlets mates with the AM which serves as a conduit for the generated gas, delivering it to the PFD inlet port.

The technology of the pyrotechnic is a scaled down version of similar gas generators made by the contractor in earlier work for aircraft escape slides and other inflatables. The technology was developed by Allied Chemical for use in the automotive passive restraint ("air bags") systems. The delivered gas is non-toxic and relatively cool due to the low burning temperature and a filter bed plus other heat control processes.

The reported testing has subjected 95 cartridges to environmental and performance evaluations designed to indicate the ability of the concept to perform suitably in emergency service after the expected handling and storage of marine usage. Environmental testing was performed by an outside test laboratory. Firings and functional evaluations were performed by ISI in its plant.

2.0 PROGRAM DESCRIPTION.

2.1 Objective of Project. The project had the objective of developing and demonstrating a solid propellant inflator for personal flotation devices. Testing included exposure of inflators to marine and probable handling environments plus firings in model life jackets and in calibrated tanks. Life jacket tests included dry and wet (underwater) firings.

The test program was designed to provide sufficient information to indicate the validity and feasibility of U.S. Coast Guard approval of the concept for use as a life saving application. The SPI would be a replacement for existing stored gas systems which are deficient in cold weather and are susceptible to undetected leakage in long term storage.

The solid propellant gas generator provides an improved performance for personal flotation devices (life saving appliances such as life jackets, vests and belts) which are intended to aid individual persons.

The reported work was aimed to developing a small solid propellant gas generator with a cool output, not damaging to the personal flotation device (PFD) or the person using it. The solid propellant inflators were designed to provide rapid, reliable inflation of PFD's at all temperatures of probable uses, including particularly, arctic regions. The design criteria were to have an inflator approximately the size of existing carbon dioxide units, to be simple in construction and reliable over long term storage. The cartridge should be better operating than the existing system.

2.1.1 Expended Cartridge Identification. An important objective of this project was to develop a means whereby a spent cartridge could be quickly identified so that inadvertent reloading of the jacket's inflatable means would be extremely unlikely. The means should be readily visible and not require the cartridge to be removed to be weighed, etc., as is the case with CO_2

The problem initially appeared to be solvable with the application of color changing paint on the base exterior of the cartridge. The storage temperature of 160°F dictated the selection of a paint which turned color at 200°F or higher and several paints were selected for testing.

It was quickly found that while the color change was effected on a cartridge activated in the air, it was not when the cartridge was immersed in water. In the latter case, readings were taken against the butt end of the cartridge (an area at least as hot as any other) with the cartridge immersed in water when activated. The recorded temperature peaked at 135°F/140°F and decreased to 98°F at the end of 4 minutes. At no point did it rise above the starting temperature.

Following this finding, a rod was implanted on the inside wall of the butt end with its end imbedded into the propellant. Color-change paint was applied to the exterior. It was believed the burning propellant would carry the generated heat to the localized point on the generator and cause the paint to change color at some elevated temperature. Again, when immersed in water, paint was unaffected because of the heatsink effect of the water.

Coincident with consideracion being given to a "window" in the cartridge wall to enable interior color change to be observed, ISI evolved a concept of implanting a hollow tube on the interior base of the cartridge, extending some 0.75" into the propellant. The tube diameter was 0.125" with an I.D. of about .080". Silicone "O" ring stock was inserted into the tube and held in place with silicone vacuum grease. The silicone stock was then snipped off flush with the cartridge exterior wall.

Upon initiation of the cartridge, the silicone cord ejects from the effect of heat expansion, leaving a visible opening in the base wall of the cartridge.

As the end of the cartridge is not covered with insulation, although protected from advertent contact by the polypropylene/foam cover, the hole is readily seen and the expended cartridge identified.

While molded silicone plugs may be later employed, or other materials and configuration, ISI believes the present system accomplishes the basic objective of the program in that it is both reliable and readily visible.

2.2 Background. The technology of the pyrotechnic is a scaled down version of gas generators made by the contractor in earlier work for aircraft escape slides and other inflatables. The technology was developed by Allied Chemical for use in the automotive passive restraint ("air bags") systems. The delivered gas is non-toxic and relatively cool due to the low burning temperature and a filter bed plus other heat control processes.

The combustion gases generated by the inflator consist of carbon dioxide (80%) and oxygen (20%), with a trace of carbon monoxide (0.5 - 0.75%). Gas composition test results on file at ISI verify the absence of other toxic constituents such as chlorine, hydrogen chloride, carbonyls, formaldahyde, nitric oxides, etc.

2.3 Apparatus.

2.3.1 Solid Propellant Inflator Design. The solid propellant inflator design evolved during the work consists of a separable gas generator cartridge of cylindrical shape and an actuating mechanism providing a lanyard-pull force to cock and fire a spring loaded firing pin which strikes a percussion primer in the cartridge, igniting its pyrotechnic train. Assembly is by screw thread. A port identical to existing PFD inlets mates with the actuating mechanism which serves as a conduit for the generated gas, delivering it to the PFD inlet port.

The solid propellant gas generator consists of the items shown in the figures as indicated as follows:

FIGURE	TITLE
2-1	Solid Propellant Gas Generator Cartridge
2-2	SPI Assembly
2-3	Actuating Mechanism

The design burst pressure of the cartridge is 1500 psi minimum. This is verified by test results. The relief device is set for 1000 psi maximum.

In the event of a blocked orifice, internal gas pressure builds up in the cartridge body until one of the two relief plugs releases. In the blocked orifice tests conducted by ISI, release of only one of the relief devices is sufficient to relieve the internal pressure to normal levels (200 psi). The two relief devices are, thus, truly redundant.

2.3.2 Heat Problem. This topic will be discussed in two parts; i.e. the activating mechanism, then the generator (inflator).

1) AM - The current production models are formed of aluminum. In the test program which preceded shipment, it was found that heat from the generator was conducted to the AM to a degree that was uncomfortable. While the heated area was confined to the section immediately adjoining the generator (with the shaft of the AM remaining cool), the condition dictated that a study be made. As the aluminum parts were about 6 weeks behind their scheduled delivery, there was insufficient time for in-depth testing of other material prior to delivery to USCG. Concurrent with the casting of aluminum parts, ISI had, however, ordered a single plug made of nylon, suitable for machining. The nylon AM was then tested as a standard assembly. When the generator was fired and for the entire time of temperature build-up following initiation, the AM remained cool to the touch or grip. No degradation of the nylon AM was observed in repeated firings.

It appears feasible to replace the aluminum material with plastic (nylon, delrin, glass-filled polycarbonate, etc.). The cost of the required dies will be significant, however, and such expense must be justified by a funded development or high-volume production program.

2) Generator - The propellant burns at a temperature of about 900^{o}F to 1000^{o}F. Through a coolant medium placed at the gas exit, the gas entering the life jacket is reduced to an average of 250^{o}F.

Heat absorption and transfer is so rapid that the gas in a fully inflated jacket is only a few degrees above ambient.

The body of the inflator, which has no interior insulation, reaches a temperature of about 600^{o}F and so must be insulated from contact with the human body. ISI investigated a number of approaches to the problem. The selected approach provides protection AND reasonable cost. This system consists of the following:

a) Corrugated phenolic -impregnated paper is wrapped around the generator and inserted into,

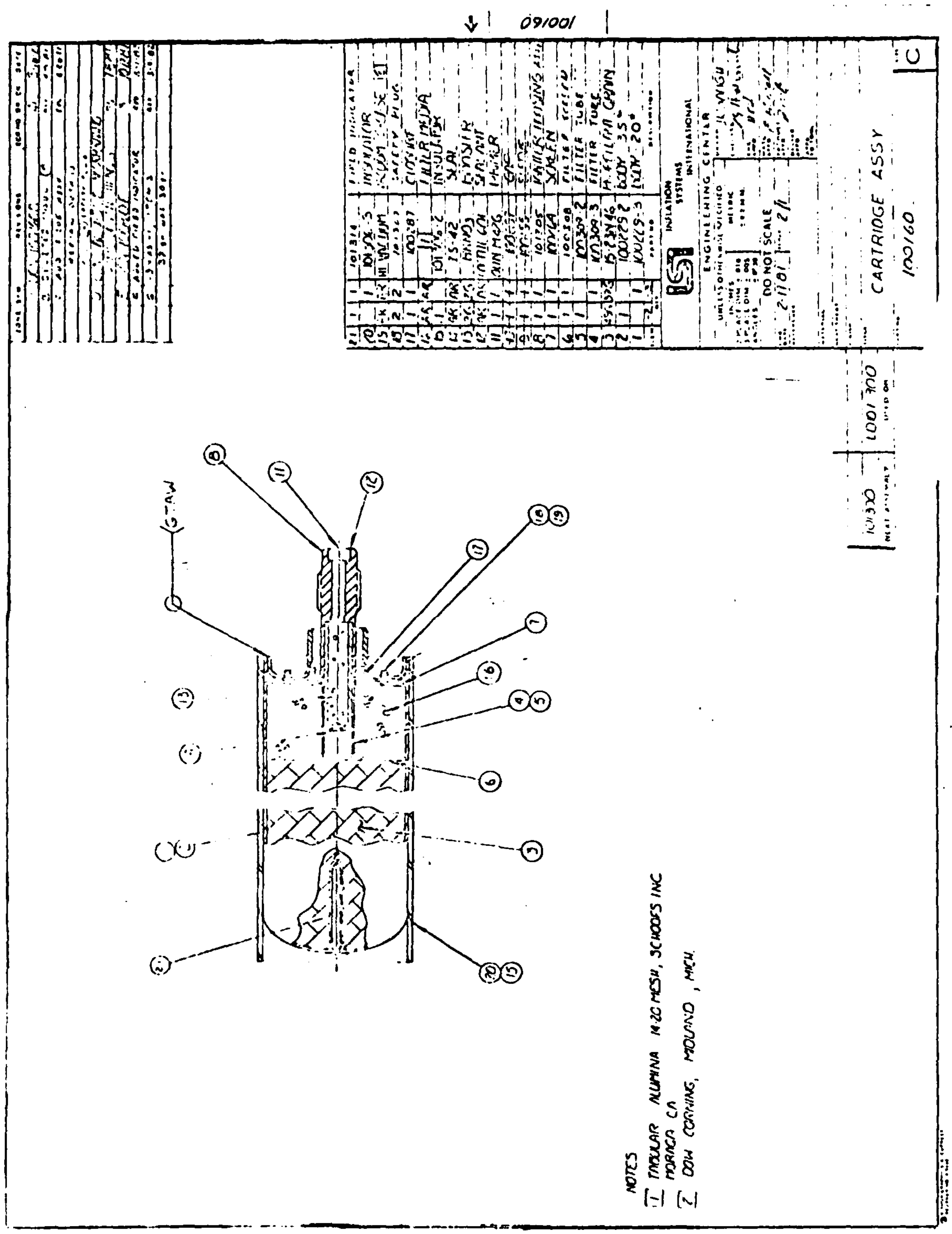

FIGURE 2-1. Solid Propellant Gas Generator Cartridge

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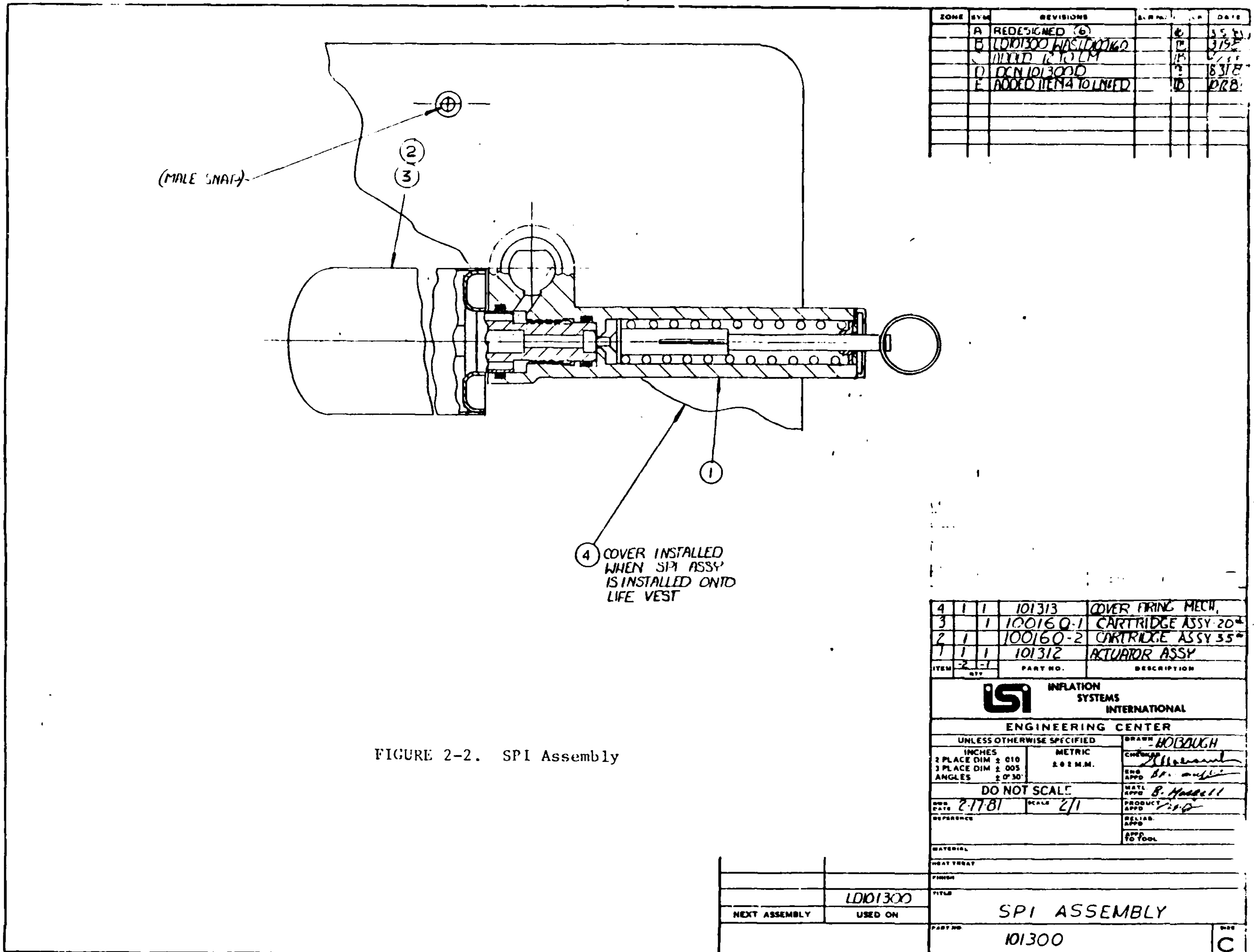
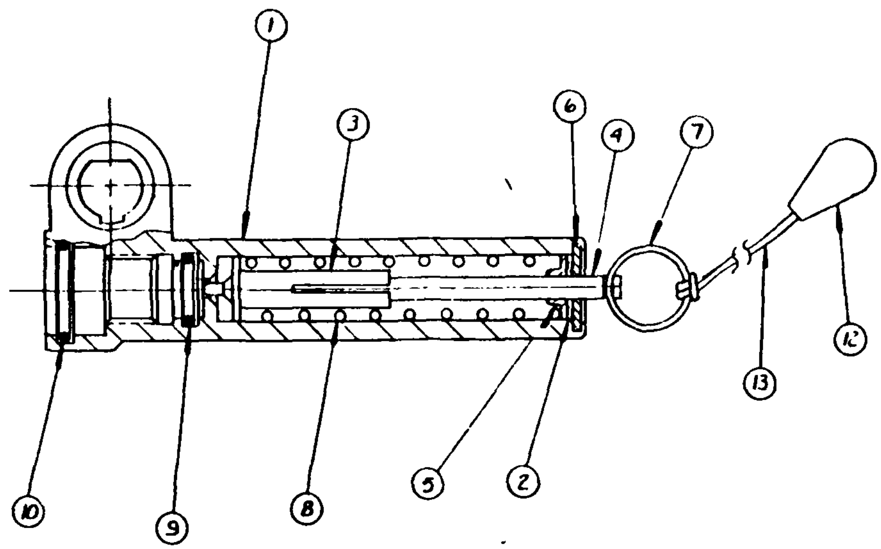


FIGURE 2-2. SPI Assembly

ZONE	SYM	REVISIONS	ECN NO	DR	CK	DATE
	A	DCN 101312 A		R		10.28.81



IDENT 56944
ISI PN 101312
LOT ______ · ___

IDENTIFY AS SHOWN
.09 HIGH CHARACTERS
USING (11)

NOTES

1. PARKER SEAL CO. CULVER CITY, CALIF.
2. LOCKWELL PRODUCTS CO., AZUSA, CALIF. MATL 302 SST QQW423.
3. SECURITY SIGNALS INC, CORDOVA, TENN.
4. INDEPENDENT INK CO. GARDENA, CALIF.
5. INFLATABLE SYSTEMS INC, ORANGE, CALIF.

ITEM	QTY	PART NO.	DESCRIPTION	
14				
13	1	2089.11	NYLON PULL CORD	5
12	1	2023.10	PULL KNOB	5
11	AR	#73X	INK PER TT-I-1795	4
10	1	2-014E515-80	O-RING	1
9	1	2-011E515-80	O-RING	1
8	1	BR22509	SPRING	3
7	1	101150C3-44.5	RING	2
6	1	101308	WASHER	
5	1	100294	SPREADER	
4	1	100293	SEAR	
3	1	100288	FIRING PIN ASSY	
2	1	100324	SEAL	
1	1	100189	HOUSING	

ISI INFLATION SYSTEMS INTERNATIONAL

ENGINEERING CENTER

UNLESS OTHERWISE SPECIFIED
INCHES: 2 PLACE DIM ± .010; 3 PLACE DIM ± .005; ANGLES ± 0°30
METRIC: ± 0.2 M M
DO NOT SCALE
DWG DATE 8.30.81 SCALE 2/1
DRAWN HOGAN
TITLE ACTUATOR ASSY
PART NO 101312 SIZE C

101300	LD 101312
NEXT ASSEMBLY	USED ON

FIGURE 2-3. Actuating Mechanism

b) A cardboard tube which has been similarly phenolic-impregnated.

c) Epoxy is then applied to bond the corrugated paper to the tube, and to the generator.

d) As is commonly found on aircraft life jackets to guard against the chill of an expended CO_2 cylinder, a woven polethylene/foam laminate is used to loosely surround the insulated generator, adding heat protection to the insulated assembly and isolating the AM from swimmer contact.

The combination inexpensively provides good protection, although somewhat bulky.

2.3.3 Model Personal Flotation Device. An initial quantity of 230 units (180 of the 20 lb. buoyancy size) were delivered to the USCG, Washington, D.C. Test inflations by USCG into a stock jacket in USCG inventory failed to fully fill the jacket, although the same inflator employed in ISI tests had pressured the specimen "20 lb." jacket to 2 psi in 2 seconds.

Investigation disclosed that the 20 lb. buoyancy claimed by the manufacturer of the jacket used by ISI in the development program was actually only 16.6 lbs., while the jacket employed in USCG tests was 22 lbs. The report of these findings is included as Figure 2-4.

The USCG reported that all tested units of the initially shipped 180 group performed as claimed by ISI when fired into the ISI specimen jacket. An additional lot, with an increase in propellant content, was subsequently forwarded to USCG and has successfully pressured the 22 lb. plus jacket.

2.3.4 Disposal of Cartridges. Fired cartridges may be disposed of by discarding in conventional trash receptacles. Each expended cartridge contains approximately 10 grams of common salt, which will leak out of the fired inflator if it is improperly disposed of in water. This is the only significant environmental effect of such disposition as seen by ISI, other than the physical presence of the steel cartridge.

Unfired cartridges are best disposed of by firing the units and disposing of the fired cartridge as above. In the event of a mis-fire, the cartridge should be returned to the supplier.

Unfired cartridges present somewhat less hazard than unfired CO_2 cylinders, since inadvertent piercing of the pressure vessel is not hazardous.

2.3.5 Compatibility of Pyrotechnic Elements. The pyrotechnic train of the inflator consists of the following elements:

INVOICE

SONIFORM, INC.
1908 FRIENDSHIP DRIVE
EL CAJON, CALIFORNIA 92020

№ 4783

INVOICE DATE: November 24, 1981
OUR ORDER NO:
YOUR ORDER NO.
TERMS: NO CHARGE
F.O.B: El Cajon, CA
SALESMAN:
SHIPPED VIA: UPS

Inflation Systems International
25977½ Sand Canyon Road
Canyon Country, CA 91351

SHIPPED TO

PPD OR C

QUANTITY	DESCRIPTION	PRICE	AMOUNT
Lot	Measure buoyancy of three (3) customer-furnished inflatable vests		n/c

Vest S.D.	Measured Buoyancy (FW)
USCG SF-20	22 lbs. 0 oz.
Seatec	16 lbs. 6 oz.

Water temp. 62°F.
Air temp. 73°F.
Bar. Pres. 29.3 in. Hg.

Measurement accuracy ± 4 oz.

On 20 Nov 81, SoniForm, Inc. measured 3 inflatable vests, as described above, for rated buoyancy in fresh water. The equipment used is of the type specified by the USCG, for the purpose and the method followed is identical to that commonly employed for determination of buoyancy of an inflatable device.

Signed

FIGURE 2-4

a) Percussion primer (M-42G)
b) Boron-potassium nitrage granules
c) Main charge propellant

As shown on ISI Drawing 100160, Cartridge Assembly, the percussion primer and the boron-potassium nitrate granules are in intimate contact in the 101305 Igniter Housing A-sembly These two component have a long history of compatible usage in thousands of military and aerospace applications. These two components are separated from the main charge propellant by a seal (Item 14 on Assembly Drawing 100160) and a gap of approximately .25 inches.

To prove extended compatibility of the pyrotechnic components, two worst case tests were conducted:

1. A unit was assembled in which the boron-potassium nitrage granules were contaminated with 25% by weight of powdered main charge propellant.

2. A second unit was assembled in which the main charge was contaminated with powdered boron-potassium nitrage, equivalent to 50% of the booster charge.

These two units were temperature cycled from -65 to +165°F, 5 cycles, then stored at +165°F for 2 days. The units were then fired at ambient temperature, with normal results.

2.4 Tests Performed and Results.

2.4.1 Phase I Design and Development Tests. The tests were conducted for the following purposes:

1) Establish propellant/coolant proportions appropriate to inflation of the specimen jackets, with gas temperatures barely above ambient.

2) Provide comparative data between CO_2 and SPI cartridge performance at -65°F, -40°F, ambient, and 160°F. Motion pictures (16mm) of life jacket deployments were taken and are on file at ISI.

Tests were conducted in accordance with test procedures submitted to, and approved by, the U.S. Coast Guard. All tests were in heavywall ("workhorse") cylinders allowing ready refurbishment and reloading for multiple tests. Pressure-time recordings were made with a Visicorder oscillograph. Differences were noted in inflatable peak pressure due to the test condition described in Appendix A.

2.4.2 Test Results. Test results were as summarized in Appendix A.

3.0 DESIGN VERIFICATION TESTS. A summary of the design verification test data from ISI Report DVT-1019 is included as Appendix A of this report.

4.0 CONCLUSIONS.

1) The SPI provides repeatable inflation of PFD's over the temperature range of -65 to +160°F, at pressures not less than the established minimum of 1.25 psi, and within the time of not over 3 seconds. In the Design Verification Test Program (detailed in Appendix A), one unit failed to function after salt fog exposure. This unit was dissected, and the failure mechanism was found to be leakage at one of the overpressure relief plugs due to damage during welding. As a result of this failure, the relief plug installation and welding procedures were modified to preclude this failure mode. The new procedure has been tested, and found to be an adequate fix.

The inflators operated at cold temperature (-65°F) sometimes produce a peak pressure at greater than 3 seconds. In each case, however, jacket pressure would have been above 1.25 psig at 3 seconds.

As discussed in Appendix A, the peak pressures observed in the jacket during the testing varied due to differences in residual air retained in the jacket prior to test, and to changes in inflated volume due to variations in the position and tension of restraining belt. Tests no. 157 and 158 exceeded the maximum allowable of 3.5 psig for these reasons. Both of these tests were conducted at ambient temperatures. The elevated temperature tests (+165°F) all produced normal jacket pressures.

2) Actuating mechanism and gas generator are functionally compatible and adequate. The problem of slightly high actuator temperature, as discussed in Section 2.3.2, will be resolved by using a plastic housing in place of the current aluminum actuator housing for production units.

3) Other sizes of gas generators can be provided by scaling upward to larger output volumes. Some reduction in size is possible, but this conclusion requires extrapolation rather than interpolation. Having produced a number of much larger units for aircraft escape slides/rafts, the entire range of inflator sizes from the PFD inflators to the raft/slide unit have shown to be available and feasible.

5.0 RECOMMENDATIONS.

1) The aluminum housing for the activating mechanism absorbs heat from its intimate contact with the inflator cartridge.

ISI produced a single housing of nylon which functioned in an entirely satisfactory manner, but without heat. ISI, therefore, recommends that the aluminum housing be replaced with plastic.

2) The expended cartridge indicator probably needs refinements, and in any case, should be fully tested to document its ability to withstand temperature cycles, humidity, salt fog, shock, vibration, etc. ISI has no plans at present for such an undertaking.

3) Attention should be given to automatic inflation and to manual override.

4) The matter of insulation should be investigated to find materials/methods to accomplish the containment of heat without the present bulk. ISI would appreciate receiving any recommendations that USCG may offer in this regard.

REFERENCES

1) ISI Test Procedure QTP - Design Verification Test Plan

2) Reliant Testing Laboratory Test Report 81-7505 covering environmental testing of DVT specimens

3) MIL-STD-810C (Envornmental TEsting) covering salt fog testing of cartridges

APPENDIX A

Summary of Design Verification Test Data from DVT-1019

Environmental Tests. Environmental tests were performed as follows:

	QTP-102 Ref. Para.
Random Vibration	6.2.2.3
Salt Fog	6.2.2.7
Humidity	6.2.2.2
Temperature Cycling	6.2.1.5

The environmental exposures were given to nine (9) solid propellant inflators (5 ea. P/N 100160-1 and 4 ea. P/N 100160-2). Details of the environmental exposures are given in the outside laboratory's test report, included here as Appendix D.

After exposures, all units were visually inspected. There was no evidence of damage to any of the specimens as a result of random vibration, humidity, and temperature cycling. Corrosion was noted on the two units exposed to salt fog (one 20 lb. and one 35 lb. unit) after 48 hours exposure to salt fog.

Function Tests. A total of 63 units were functioned in the DVT. The DVT quantities and assignment of units to the various tests are shown in Figure A-1. Figure A-1 also gives the performance data on the firing tests - peak pressure and time to peak.

PROBLEMS.

Belt Adjustment. Belt adjustment was found to have a significant effect on peak pressure. This was demonstrated during Test #7, Shot LF-067, when the belt became hooked on a portion of the test stand while the inflatable was being vacuumed. When inflation occurred, the belt was then not free to position itself and became excessively tight. This was corrected 45 seconds into the test by unhooking the belt off the test stand and allowing it to seek its own position, but this resulted in a .4 psi pressure drop in the inflatable.

Additional variations in ultimate pressure can occur from differences in the extent of vacuuming of a jacket prior to packaging or to re-use. None of these variables are any different than what would occur from CO_2 inflation, and then only apply to jacket design and operating instructions rather than to the inflator.

Air Retention in Inflatable during Vacuuming. Prior to each test, each inflatable was vacuumed down through the fitting used to measure inflatable interior pressure. Vacuum line was then removed and pressure transducer hose was attached. Due to stiffness of the fabric in specimen inflatables, it was difficult to achieve the same degree of vacuum from test to test.

Temperature recordings were taken during pre-Phase I testing, but were found to be slight cause for pressure change, thus, the pressure drops from peak to residual is held to be due to material stretch. This was corroborated by filling inflatables with shop air and monitoring pressure drop over a 5-minute period.

Repeated cycling of the two actuator mechanisms caused failures of the mechanisms at 348 cycles and 390 cycles. While this is less than the required 500 cycles, the portion of the actuating mechanism that failed (firing pin latching arm) is a qualified fuze component for Army use (Army P/N 8822514). The part failed in a fatigue mode (cracking of the latching arm). Fatiguing of this part is unlikely to occur at fewer than 200 cycles, which is well above the expected requirements for life jacket applications. No other suspect failure modes were foreseen as a result of this testing.

Test Data Summaries. The firing data for DVT units are summarized in figures as follows:

Figure A-2	Data for Post-Environment Firings
Figure A-3	Tank Firings - 20 lb. Cartridges
Figure A-4	Tank Firings - 35 lb. Cartridges
Figure A-5	Life Jacket Tests - 20 lb. Cartridges
Figure A-6	Life Jacket Tests - 35 lb.-Cartridges
Figure A-7	20 lb. Cartridges - Combined Tank & Jacket
Figure A-8	35 lb. Cartridges - Combined Tank & Jacket
Figure A-9	All DFT Firings Combined

Original Data Recordings. Original oscillograms recording DVT are available for reference by USCG. Copies of any or all will be provided on request. All original data have been reduced and are presented in the summaries of this report. The plots and summaries provide an easier mode of reference to analyze the test information than reference to the original raw data.

Calibration records for instruments are also available for reference as desired by the customer.

All original records will be retained for the life of the contract.

DVT PERFORMANCE TEST DATA

SOLID PROPELLANT INFLATOR FOR PERSONAL FLOTATION DEVICES (SPI/PFD)

TEST NUMBER	20-LB	35-LB	TANK	DRY JACKET	WET JACKET	OTHER	FIRING TEMPERATURE				PEAK PRESSURE (psi)	TIME TO PEAK (sec)	NOTES
							-65°F	-40°F	Amb (70°F)	+160°F			
1001	X					Blocked			X		975	.24	
1002		X				Blocked			X		1050	.34	
1003		X	X						X		2.9	1.7	
1004		X	X						X		3.0	1.2	
1005		X	X						X		3.1	1.5	
1006	X		X						X		2.0	1.2	
1007	X		X						X		2.1	1.4	
1008	X		X						X		2.0	1.1	
1009		X	X							X	3.3	1.0	
1010		X	X							X	3.2	1.1	
1011	X		X							X	2.2	1.0	
1012	X		X							X	2.1	0.9	
1013	X		X			Temp Cycl			X		1.9	0.8	
1014	X		X			Humidity			X		2.2	1.0	
1015	X		X			Rand Vib			X		1.9	2.0	
1016	X		X			Salt Fog			X		-0-	-0-	Note (1)
1017	X		X			Drop			X		2.0	1.2	

Figure A-1

DESIGN VERIFICATION TEST -- SPI/PFD cont'd

TEST NUMBER	20-LB	35-LB	TANK	DRY JACKET	WET JACKET	OTHER	FIRING TEMPERATURE -65°F	FIRING TEMPERATURE -40°F	FIRING TEMPERATURE Amb	FIRING TEMPERATURE +160°F	PEAK PRESSURE (psi)	TIME TO PEAK (sec)
1018		X	X			Temp Cycle			X		3.0	1.6
1019		X	X			Temp Cycle			X		3.1	1.1
1020		X	X			Humidity			X		2.9	1.5
1021		X	X			Rand Vib			X		3.1	1.3
1022		X	X			Salt Fog			X		3.1	1.5
1023		X	X				X				2.6	3.5
1024		X	X				X				2.8	2.1
1025		X	X				X				2.7	2.2
1026	X		X				X				1.7	0.8
1027	X		X				X				1.7	2.1
1028	X		X				X				1.7	3.1
1029		X		X					X		3.4	1.3
1030		X		X					X		3.4	1.4
1031		X			X				X		2.9	1.7
1032		X			X				X		2.3	1.7
1033		X		X						X	2.8	0.8
1034	X		X							X	2.2	0.8

Figure A-1

DESIGN VERIFICATION TEST -- SPI/PFD cont'd													
TEST NUMBER	20-LB	35-LB	TANK	DRY JACKET	WET JACKET	OTHER	FIRING TEMPERATURE				PEAK PRESSURE (psi)	TIME TO PEAK (sec)	
							-65°F	-40°F	Amb	+160°F			
1035		X	X							X	3.4	1.3	
1036		X	X			H_2O SOAK			X		3.2	1.4	
1037		X	X			H_2O SOAK			X		3.1	1.4	
1038	X		X			H_2O SOAK			X		2.0	1.2	
1039	X		X			H_2O SOAK			X		2.1	1.9	
1040		X		X						X	3.4	0.8	
1041		X			X					X	3.2	1.1	
1042	X			X						X	3.5	0.4	
1043	X			X						X	3.8	0.4	Note (2)
1044	X			X			X				3.1	1.0	
1045	X			X			X				3.3	0.8	
1046		X		X			X				1.6	1.8	
1047		X		X			X				1.6	1.2	
1048													Not used
1049		X			X		X				2.1	3.0	
1050	X				X		X				3.0	0.4	
1051	X				X					X	2.8	0.5	
1052		X		X				X			2.7	0.8	

Figure A-1

DESIGN VERIFICATION TEST -- SPI/PFD cont'd

TEST NUMBER	20-LB	35-LB	TANK	DRY JACKET	WET JACKET	OTHER	FIRING TEMPERATURE -65°F	-40°F	Amb	+160°F	PEAK PRESSURE (psi)	TIME TO PEAK (sec)	NOTES
1053	X			X				X			2.5	1.6	
1054	X		X					X			1.8	1.5	
1055		X	X			Drop			X		2.9	2.2	
1056		X	X					X			2.6	3.2	
1057	X			X					X		4.3	0.7	Note (2)
1058	X			X					X		4.3	0.5	Note (2)
1059	X				X				X		2.3	Lost	Note (3)
1060	X				X				X		2.6	1.6	

NOTES:

(1) One relief plug was not seated properly, allowing salt fog intrusion into the cartridge and consequent failure of the propellant to ignite. Percussion primer and ignition train burned to the propellant.

(2) Peak pressure in two 20-lb dry jacket firings exceeded the maximum allowable of 3.5 psi.

(3) Time reference was lost when oscillograph paper failed to start.

Figure A-1

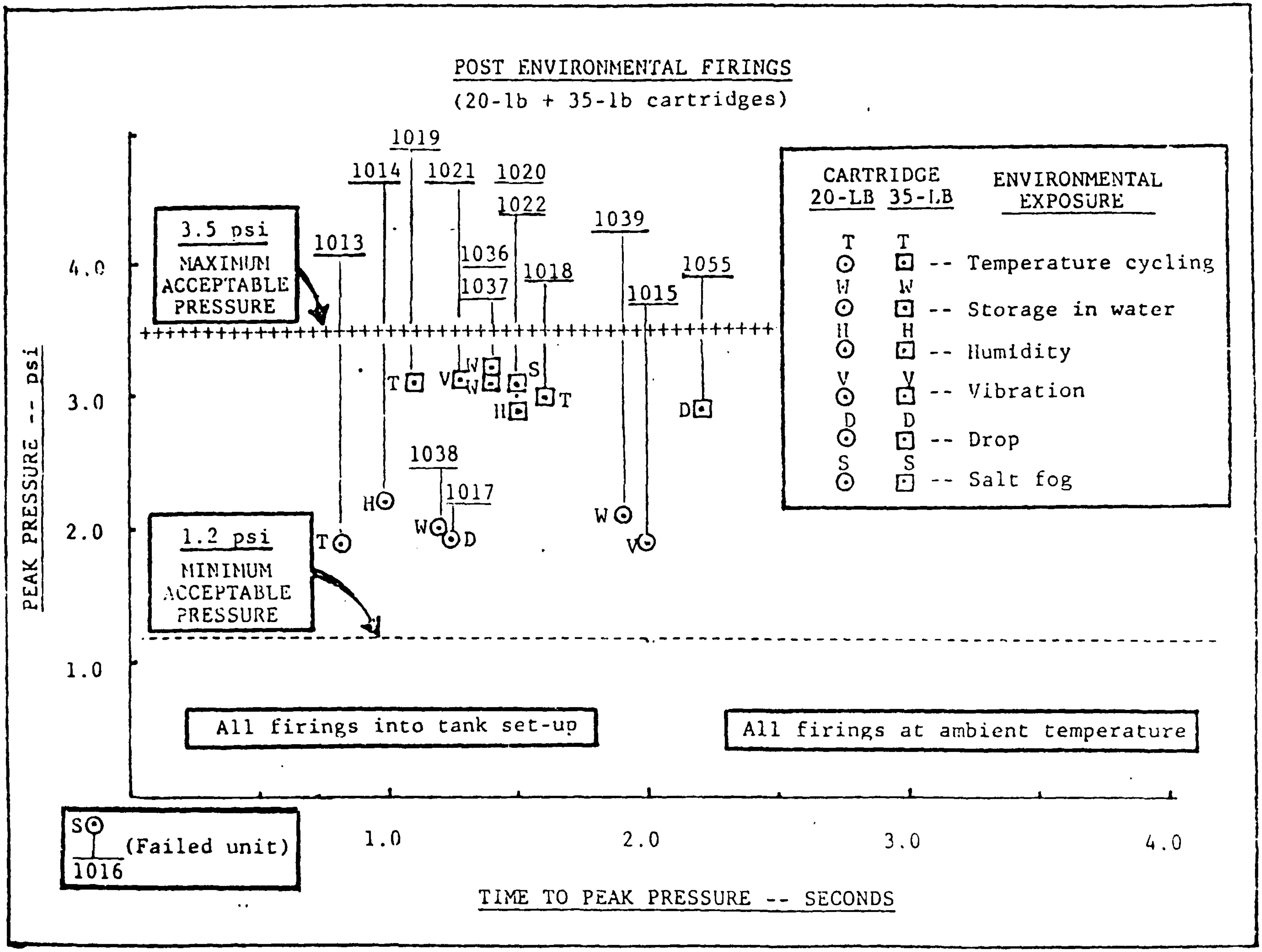

POST ENVIRONMENTAL FIRINGS
(20-lb + 35-lb cartridges)
3.5 psi
MAXIMUM ACCEPTABLE PRESSURE
1.2 psi
MINIMUM ACCEPTABLE PRESSURE
1013
1014
1019
1021
1020
1022
1036
1037
1018
1039
1015
1055
1038
1017
CARTRIDGE
20-LB 35-LB
ENVIRONMENTAL EXPOSURE
T -- Temperature cycling
W -- Storage in water
H -- Humidity
V -- Vibration
D -- Drop
S -- Salt fog
All firings into tank set-up
All firings at ambient temperature
S
1016
(Failed unit)
PEAK PRESSURE -- psi
TIME TO PEAK PRESSURE -- SECONDS
4.0
3.0
2.0
1.0

Figure A-2

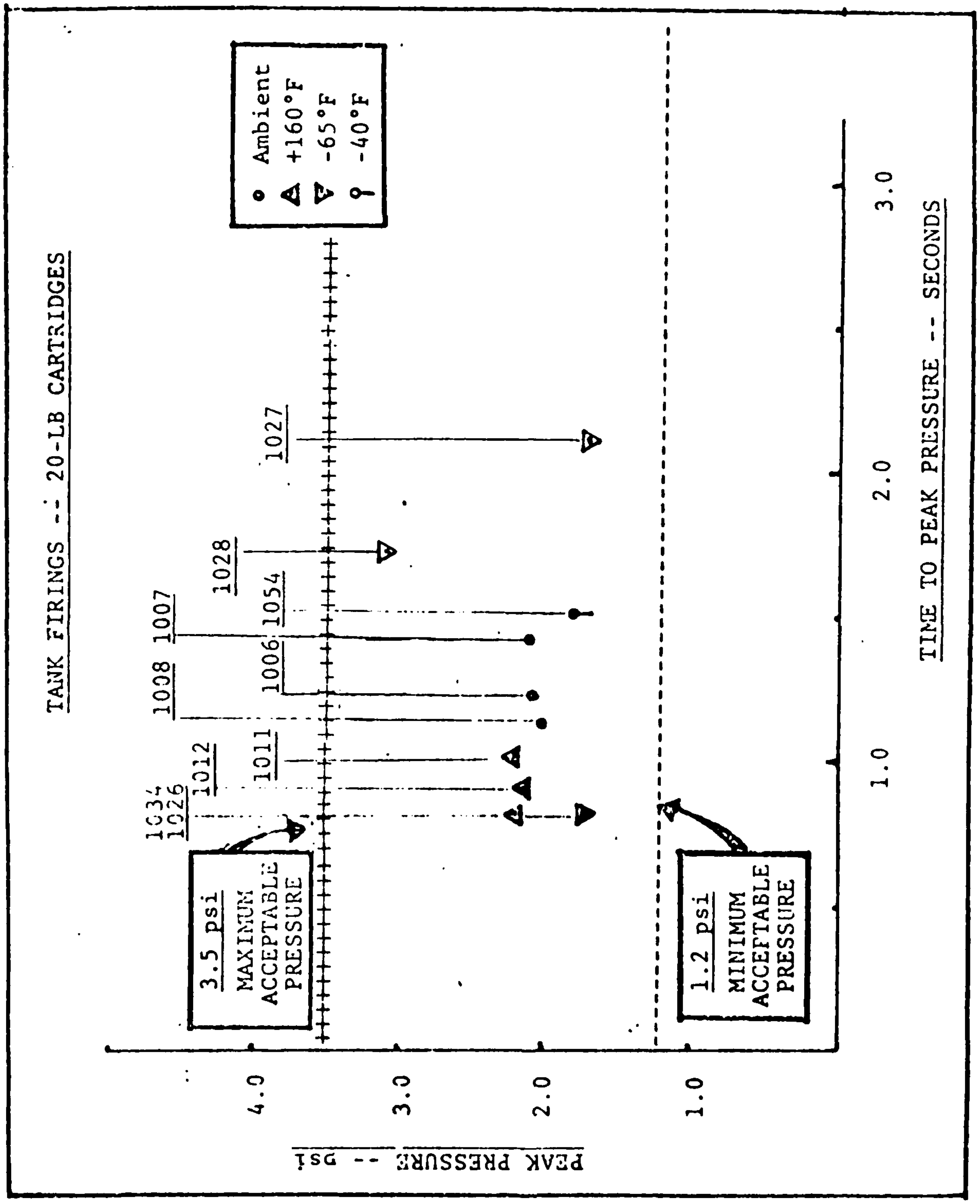

TANK FIRINGS -- 20-LB CARTRIDGES
Ambient
+160°F
-65°F
-40°F
1027
1028
1054
1007
1006
1008
1011
1012
1034
1026
3.5 psi
MAXIMUM ACCEPTABLE PRESSURE
1.2 psi
MINIMUM ACCEPTABLE PRESSURE
4.0
3.0
2.0
1.0
PEAK PRESSURE -- psi
1.0
2.0
3.0
TIME TO PEAK PRESSURE -- SECONDS

Figure A-3

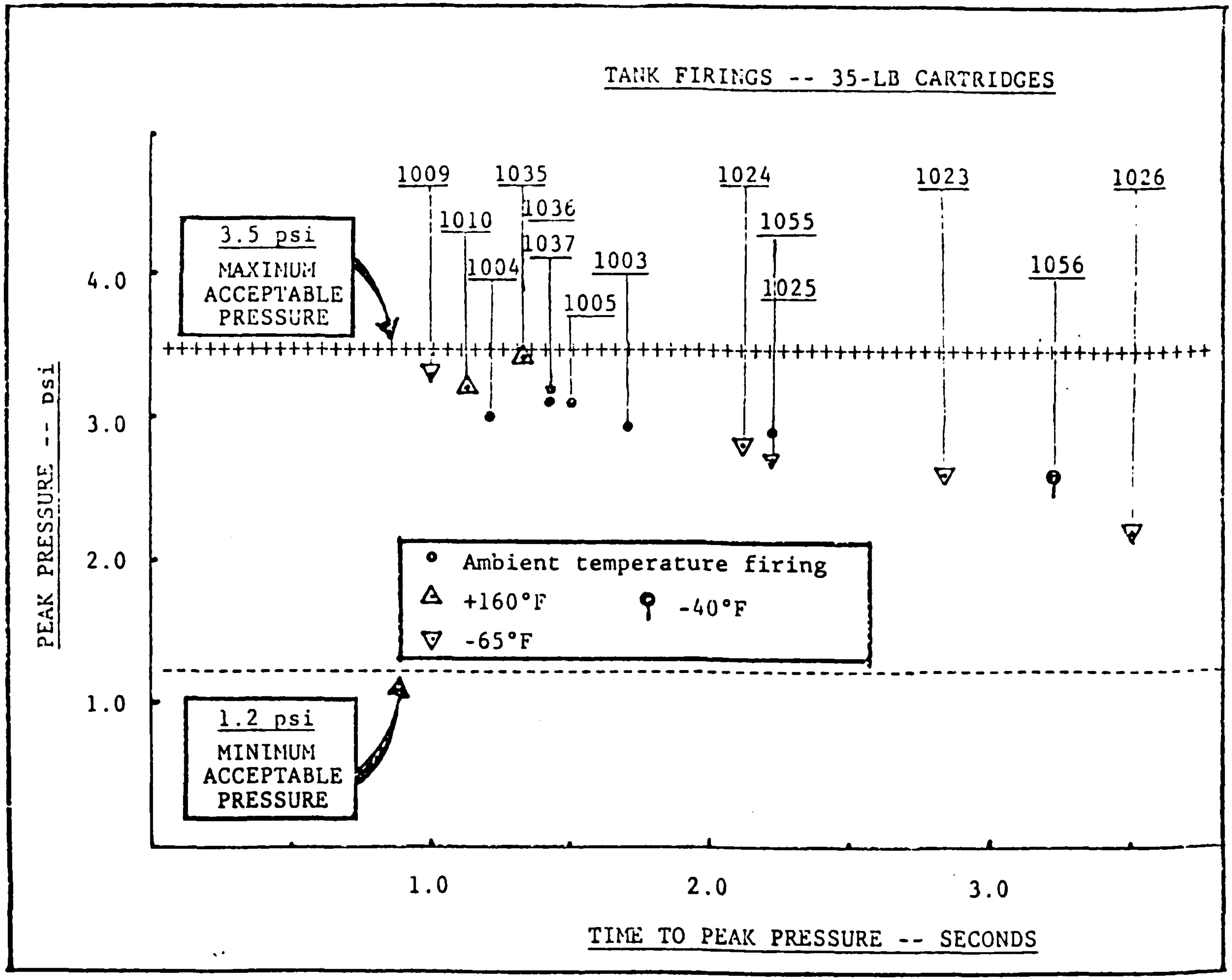

TANK FIRINGS -- 35-LB CARTRIDGES
3.5 psi
MAXIMUM
ACCEPTABLE
PRESSURE
1.2 psi
MINIMUM
ACCEPTABLE
PRESSURE
1009
1010
1004
1035
1036
1037
1005
1003
1024
1055
1025
1023
1056
1026
Ambient temperature firing
+160°F
-40°F
-65°F
PEAK PRESSURE -- psi
4.0
3.0
2.0
1.0
1.0
2.0
3.0
TIME TO PEAK PRESSURE -- SECONDS

Figure A-4

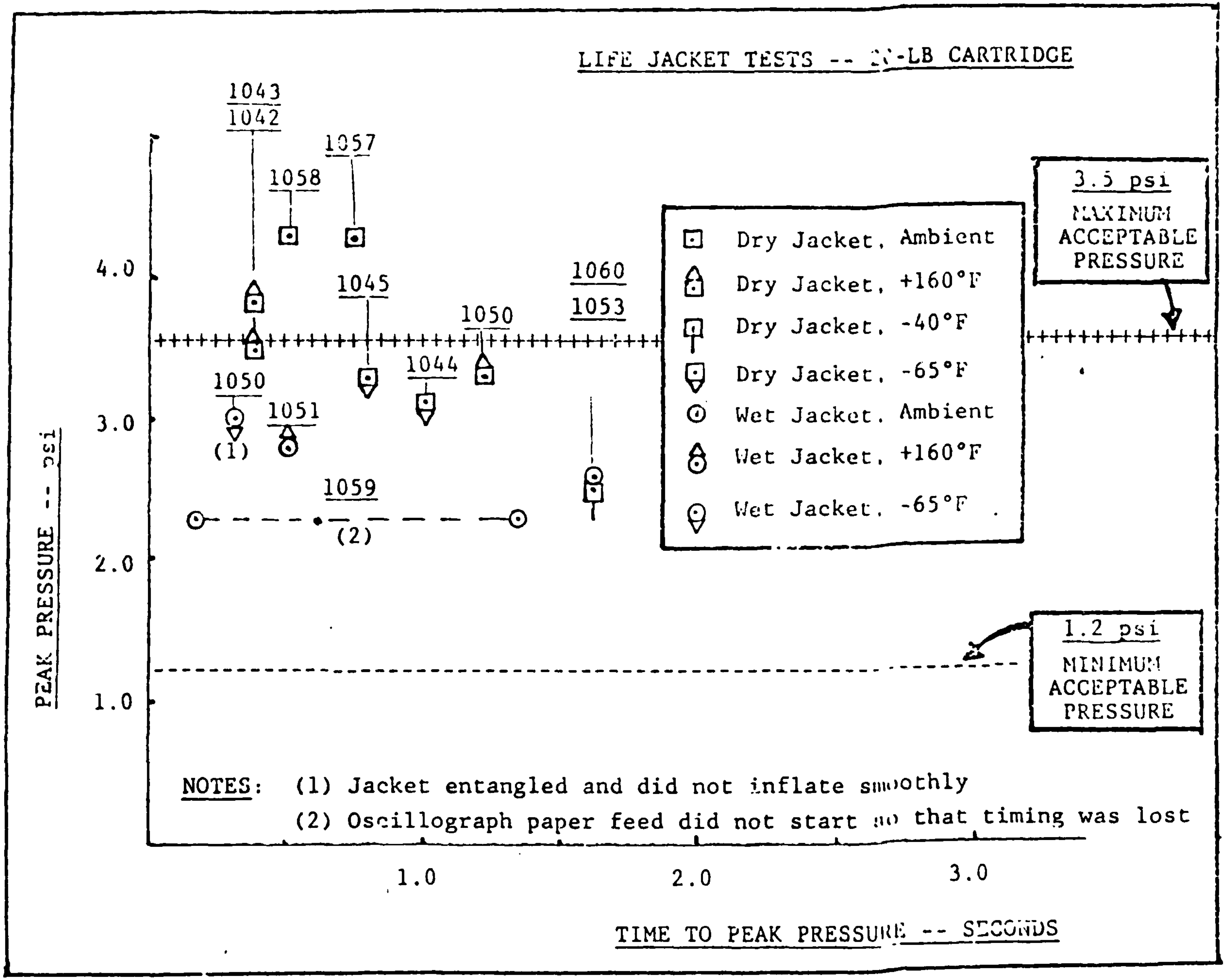
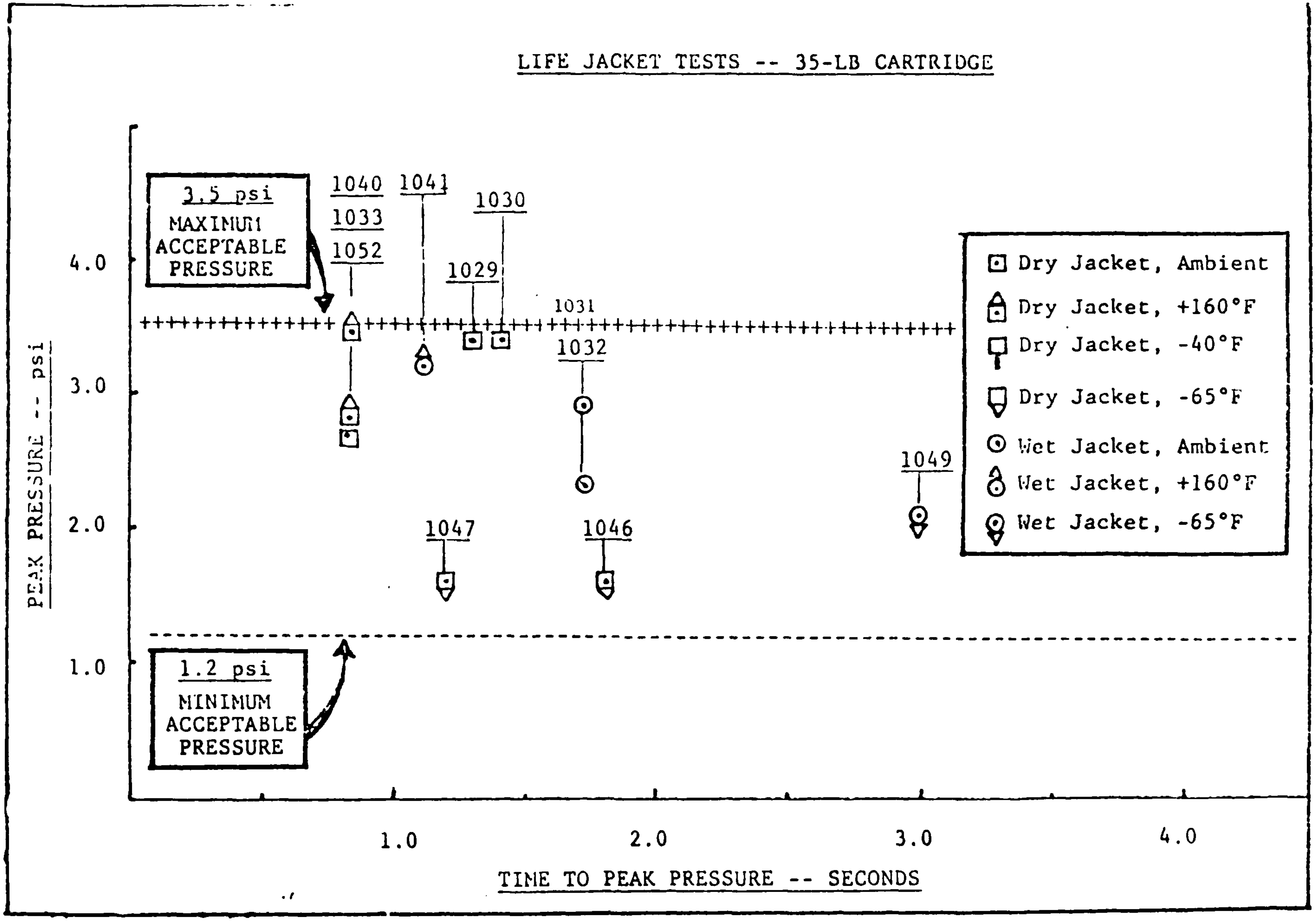

LIFE JACKET TESTS -- -LB CARTRIDGE
PEAK PRESSURE -- psi
4.0
3.0
2.0
1.0
1043
1042
1058
1057
1045
1050
1044
1060
1053
1050
(1)
1051
1059
(2)
Dry Jacket, Ambient
Dry Jacket, +160°F
Dry Jacket, -40°F
Dry Jacket, -65°F
Wet Jacket, Ambient
Wet Jacket, +160°F
Wet Jacket, -65°F
3.5 psi
MAXIMUM ACCEPTABLE PRESSURE
1.2 psi
MINIMUM ACCEPTABLE PRESSURE
NOTES: (1) Jacket entangled and did not inflate smoothly
(2) Oscillograph paper feed did not start so that timing was lost
1.0
2.0
3.0
TIME TO PEAK PRESSURE -- SECONDS

Figure A-5



LIFE JACKET TESTS -- 35-LB CARTRIDGE
3.5 psi
MAXIMUM
ACCEPTABLE
PRESSURE
1.2 psi
MINIMUM
ACCEPTABLE
PRESSURE
1040
1033
1052
1041
1030
1029
1031
1032
1049
1047
1046
Dry Jacket, Ambient
Dry Jacket, +160°F
Dry Jacket, -40°F
Dry Jacket, -65°F
Wet Jacket, Ambient
Wet Jacket, +160°F
Wet Jacket, -65°F
4.0
3.0
2.0
1.0
PEAK PRESSURE -- psi
1.0
2.0
3.0
4.0
TIME TO PEAK PRESSURE -- SECONDS

Figure A-6

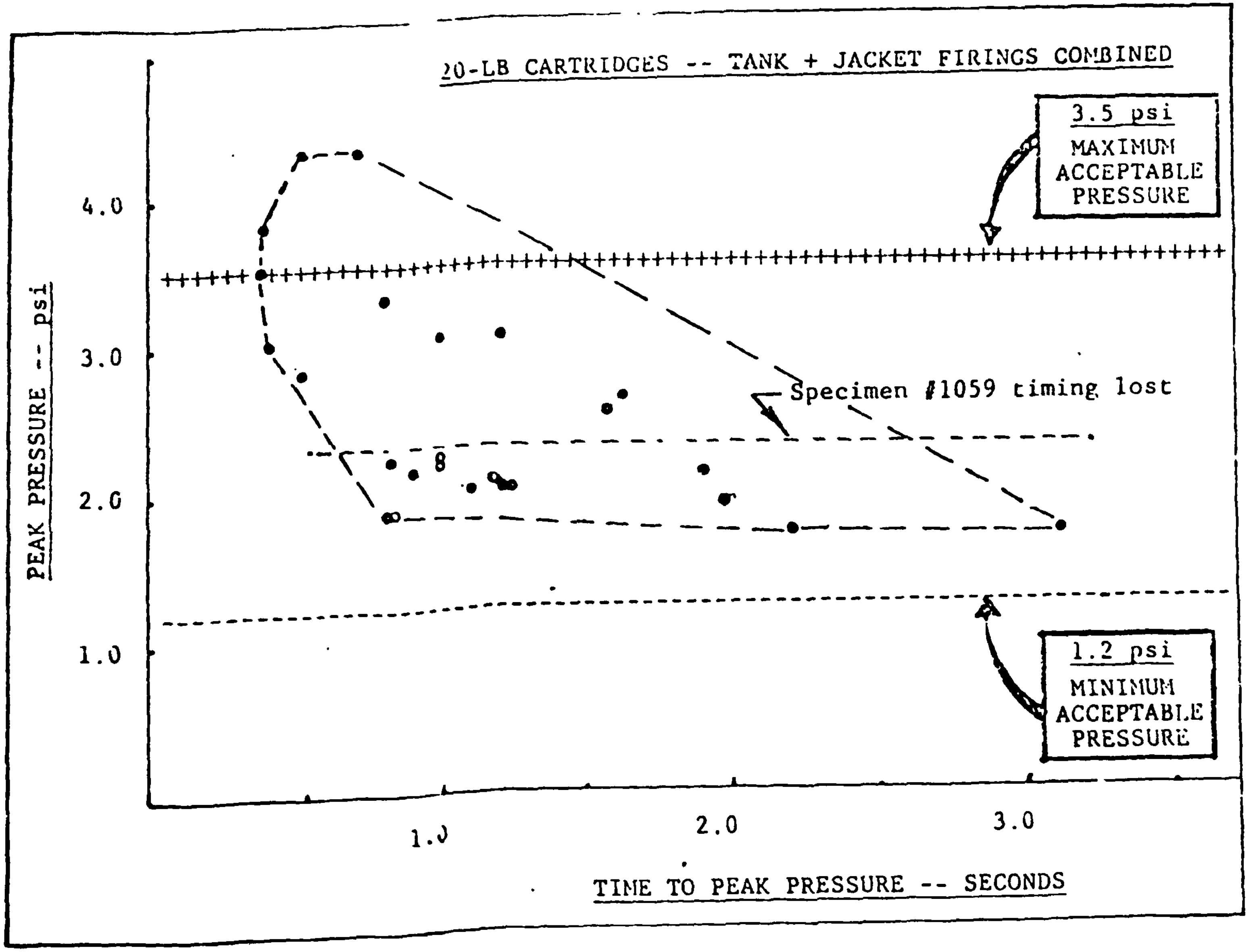

20-LB CARTRIDGES -- TANK + JACKET FIRINGS COMBINED
3.5 psi
MAXIMUM
ACCEPTABLE
PRESSURE
Specimen #1059 timing lost
1.2 psi
MINIMUM
ACCEPTABLE
PRESSURE
PEAK PRESSURE -- psi
4.0
3.0
2.0
1.0
1.0
2.0
3.0
TIME TO PEAK PRESSURE -- SECONDS

Figure A-7

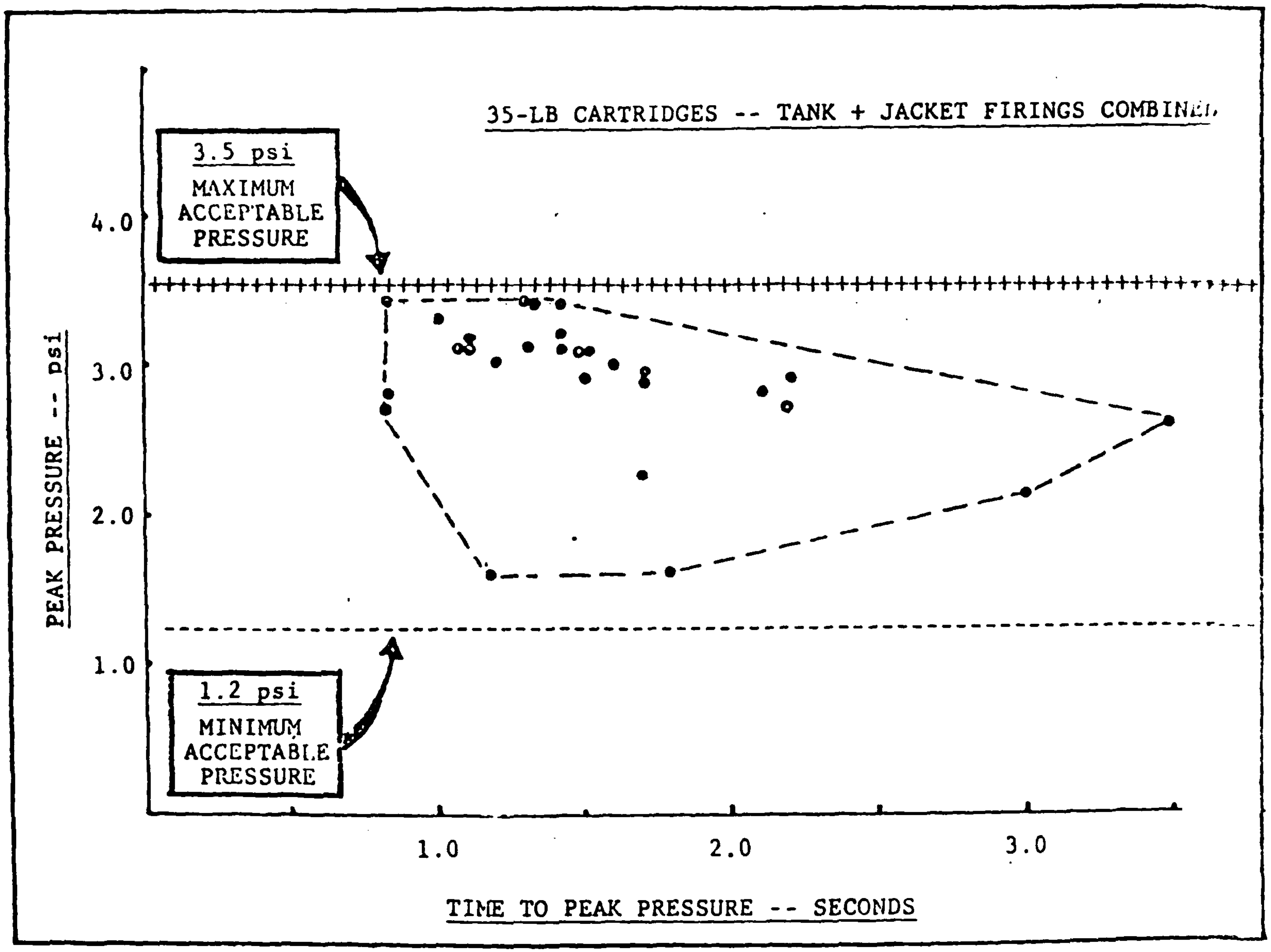

35-LB CARTRIDGES -- TANK + JACKET FIRINGS COMBINED
3.5 psi
MAXIMUM
ACCEPTABLE
PRESSURE
1.2 psi
MINIMUM
ACCEPTABLE
PRESSURE
PEAK PRESSURE -- psi
4.0
3.0
2.0
1.0
1.0
2.0
3.0
TIME TO PEAK PRESSURE -- SECONDS

Figure A-8

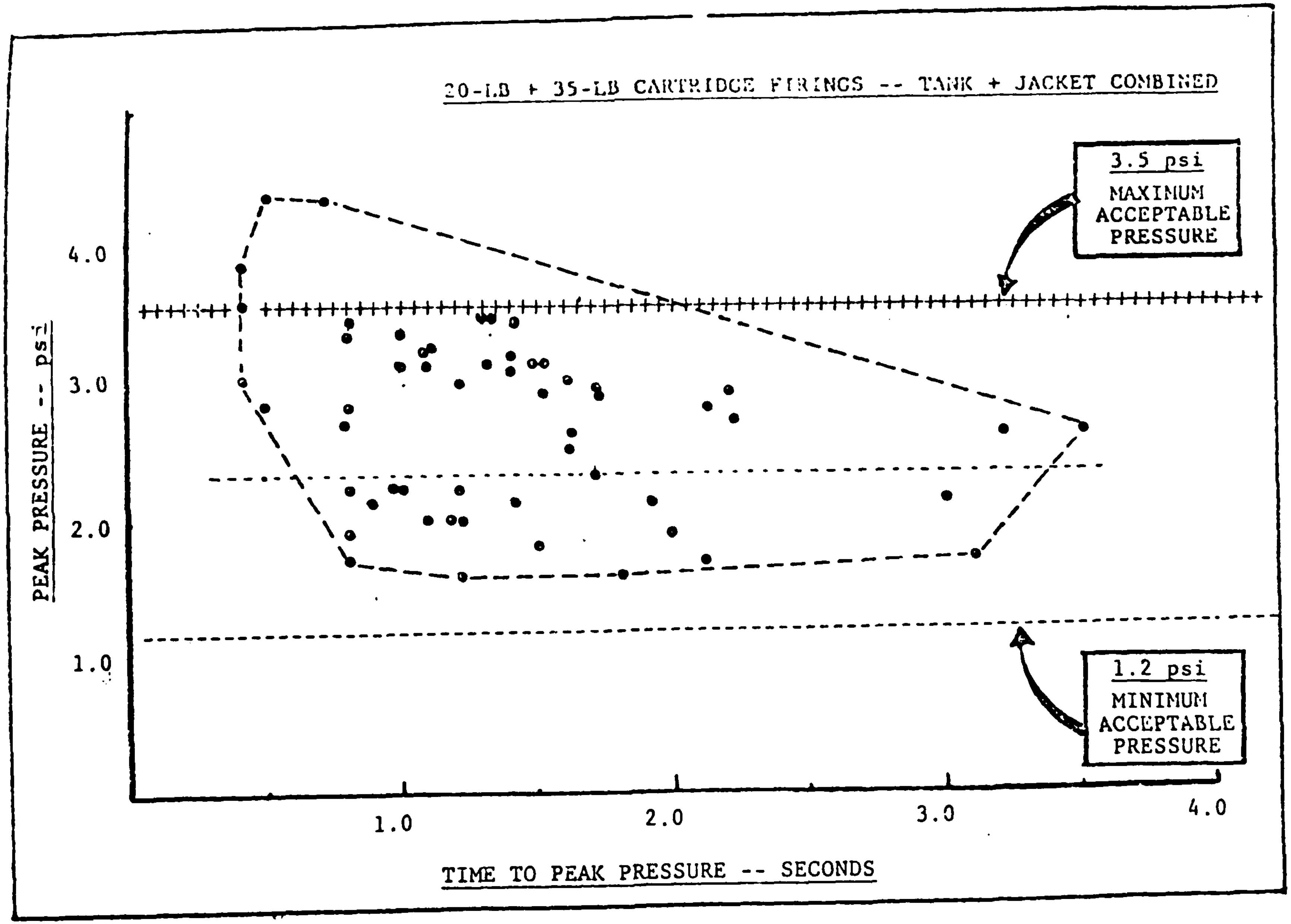

20-LB + 35-LB CARTRIDGE FIRINGS -- TANK + JACKET COMBINED
3.5 psi
MAXIMUM
ACCEPTABLE
PRESSURE
1.2 psi
MINIMUM
ACCEPTABLE
PRESSURE
PEAK PRESSURE -- psi
4.0
3.0
2.0
1.0
1.0
2.0
3.0
4.0
TIME TO PEAK PRESSURE -- SECONDS

Figure A-9

APPENDIX B

Abstract of the Phase I Test Report - ISI TR1013

The Phase I Test Program utilized heavyweight machined housings for the gas generating cartridge. Otherwise, the internal workings of the gas generator were identical to the prototype design. The test program consisted of 40 developmental firings to establish the required propellant and coolant proportions, nozzle sizes, etc. An additional 40 firings were made to provide comparative data between CO_2 bottles and solid propellant inflators (SPI's) at conditioning temperatures of -65°F, -40°F, ambient temperature, and +160°F. Results of these tests are detailed in the following figure, Figure B-1.

COMPARATIVE PERFORMANCE CHART
SOLID PROPELLANT INFLATOR VS. CO_2 SYSTEM

SPI SYSTEM (SOLID PROPELLANT INFLATOR)				CO_2 SYSTEM
SPECIMEN TYPE AND BUOYANCY RATING	TIME TO 2 PSI PRESSURE SECONDS (SPI)	TEMP. COND.	SECONDS (CO_2)	SPECIMEN TYPE, CARTRIDGE SIZE AND BUOYANCY RATING
R-1 - 20#	1.1	Amb.	3.5	R-1, 16gm, 20#
R-1 - 20#	1.25	Amb.	4.0	R-1, 16gm, 20#
R-1 - 20#	.95	Amb.	5.2	R-1, 16gm, 20#
R-1 - 20#	1.05	Amb.	----	— — —
R-1 - 20#	1.2	Amb.	----	— — —
R-2 - 35#	1.7	Amb.	4.2	R-2, 16gm, 35#
R-2 - 35#	1.4	Amb.	7.0	R-2, 16gm, 35#
R-2 - 35#	1.9	Amb.	----	— — —
R-2 - 35#	1.6	Amb.	----	— — —
R-2 - 35#	1.4	Amb.	----	— — —
AVERAGE	1.365		4.78	
R-1 - 20#	1.61	-40°F	10.5	R-1, 16gm, 20#
R-1 - 20#	1.75	-40°F	12.5	R-1, 16gm, 20#
R-1 - 20#	2.0	-65°F	270.0	R-1, 16gm, 20#
R-1 - 20#	2.4	-65°F	----	— — —
R-2 - 35#	2.3	-40°F	----	— — —
	2.9	-40°F	11.0	R-2, 26gm, 35#
AVERAGE	2.16 -40°F/-65°F		11.35 @ -40°F 270.0 @ -65°F	
R-2 - 35#	.85	+160°F	----	— — —
R-2 - 35#	.9	+160°F	----	— — —
			4.0	R-1, 16gm, 20#
			5.0	R-1, 16gm, 20#
			6.0	R-2, 26gm, 35#
AVERAGE	.875		5.0	

NOTE: Minimum Pressures at 5 Minutes - 1.5 psi; Maximum at 5 Minutes - 3.9 psi

DESIGN VERIFICATION TEST PLAN - REVISED

6.2 DESIGN VERIFICATION TEST PLAN.

6.2.1 Temperature/Environmental Range.

CODE: DRY firings will be into R-1 or R-2 specimen jackets

WET firings will be into R-1 or R-2 specimen jackets submerged in water to 2 foot depth. Surfacing with inflation.

TANK firings will be made to establish fixed performance criteria for follow-on Acceptance Testing

		20# R-1+AM	35# R-2+AM
6.2.1.1 Ambient.			
Dry		2	2
Wet		2	2
Tank		3	3
6.2.1.2 Low Temperature, -65°F.			
Dry		2	2
Wet		1	1
Tank		3	3
Dry	-40°F	1	1
Tank		1	1
6.2.1.3 High Temperature, +160°F.			
Dry		2	2
Wet		1	1
Tank		3	3

6.2.1.4 Surface Temperature.

Measurements of surface temperatures will be taken in the following manner,

a) Two each 20# and 35# specimens, fitted with thermocouples shall, as a minimum, be positioned to record the temperature of the aft side wall and the gas exit end of the cartridge over a period of 5 minutes from actuation.

Additionally, any area of the activator which is significantly warmed by its connection to the cartridge, or by gas expelled from the cartridge, shall also be fitted with thermocouples and temperature recorded.

The instrumentation shall be recorded continuously for a period of five (5) minutes from actuation.

NOTE: The maximum heat generated in aircraft slide inflators has been found to occur within 5 minutes of activation. It is believed the SPI for life jackets will reach maximum temperature within the same period, but if it is found to be longer, the recording time will be extended.

6.2.1.5 Temperature Cycling.

One (1) 20# and two (2) 35# cartridges shall be mounted without thermal protection in a facility capable of controlled temperature cycling between -65°F and +160°F and subjected without interruption through the 25 cycles.

On completion of the cycling, the inflators shall be fired at ambient and performance shall be as specified in para. 6.2.1.1 (Tank).

The cartridges will be conditioned at -65°F for 30 minutes and then be conditioned at +160°F for 30 minutes, making a complete cycle every hour for 25 hours.

6.2.2 Tests other than Temperature.

6.2.2.1 Storage in Water.

At 2.0 ft. depth, stow exposed cartridges for 8 hours, then fire into tank. Measure time and pressure to confirm normal performance (to simulate condition where spare cartridges or jackets are stowed in wet bilge). Two (2) each 20# and 35# cartridges, with AMs, shall be so tested.

6.2.2.2 Humidity/Leakage.

One (1) each 20# and 35# cartridge shall be tested by Reliant Test Laboratory in accordance with MIL-STD-810C, Method 507-1, Procedure 1.

6.2.2.3 Vibration.

One each 20# and 35# cartridge, mated with AMs, to be tested by Reliant in accordance with the following (or as modified to suit size and type of article).

The test item shall be subjected to 30 minute random vibration in each of three axis in accordance with the test envelope, shown in Figure 1. The vibration shall have gaussion distribution. Instantaneous peaks may be limited to three times the rms value, and resonant modes of the test items within the test frequency range shall be equalized or compensated. The overall acceleration shall be recorded during each axis and shall be monitored continuously with a true rms meter during the test to maintain the required tolerance. The pre-test runs may be repeated if necessary to make spectrum corrections. Filters may be used, if needed to attenuate signals above 2000 cps.

Random vibration spectra, when analyzed as above, shall be within the following tolerances on acceleration power spectral density applied to equipment under 50 pounds in weight.

Between 5 cps and 50 cps, +6 db, -3 db, -+300%, 50%
Between 50 cps and 1000 cps, +3 db, -+100%, -50%
Between 1000 cps and 2000 cps, -+ 1.5 db, -+41%, -29%

Overall acceleration must be kept within +20% and -5%.

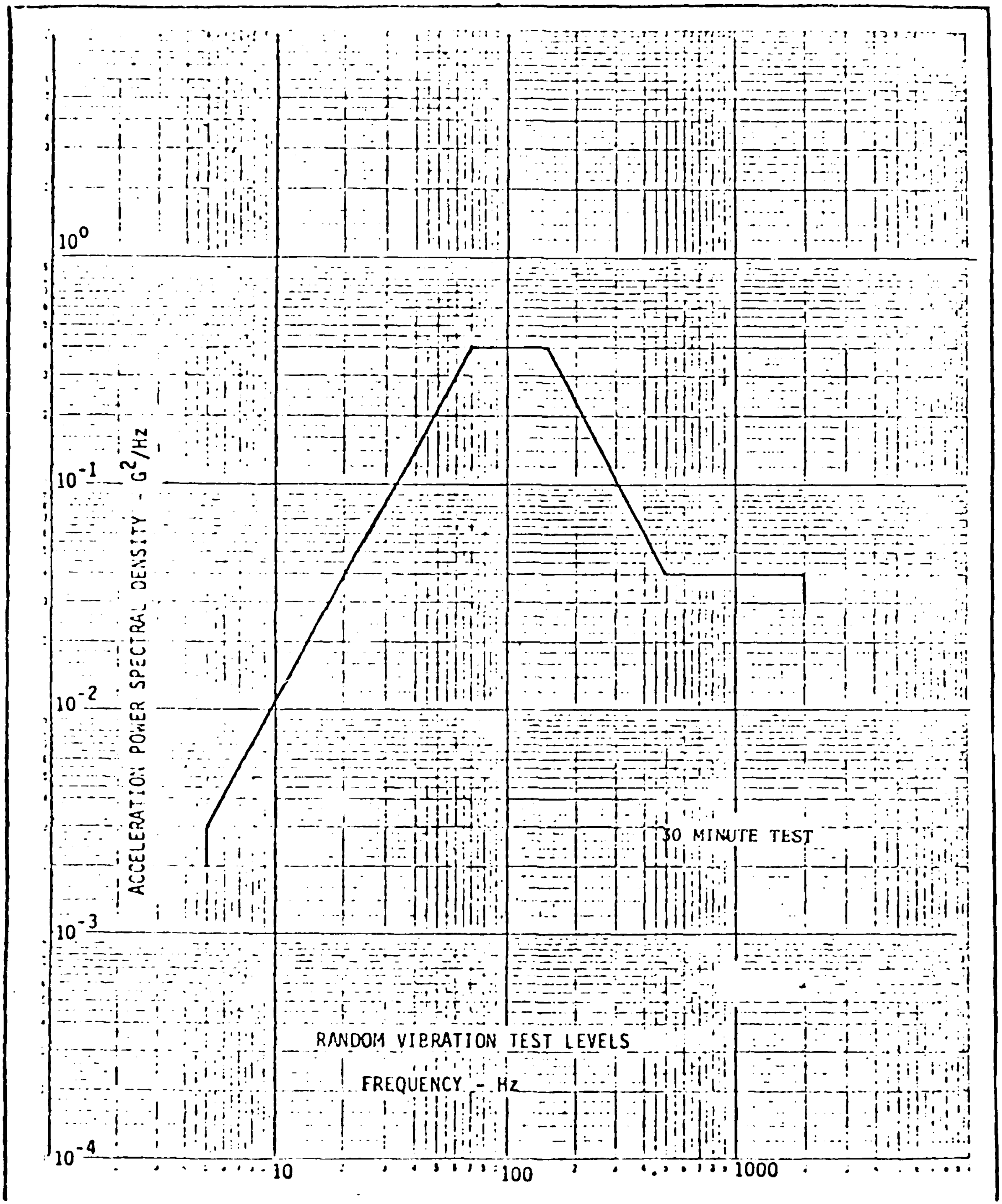

10^0
10^-1
10^-2
10^-3
10^-4
ACCELERATION POWER SPECTRAL DENSITY - G^2/Hz
30 MINUTE TEST
RANDOM VIBRATION TEST LEVELS
FREQUENCY - Hz
10
100
1000

FIGURE 1

6.2.2.4 Drop/Shock.

In accordance with USCG directive, the test as proposed, will be modified as follows:

One (1) each 20# and 35# cartridge shall be dropped from a 5' height onto steel plate on concrete pad. The specimens shall be programmed to successively impact on the butt end, side (horizontal), and orifice end first.

The 35# inflator shall then be mated with the AM and three similar drops made, except that "orifice" shall be "pull cord".

Upon completion of these drops, the specimens shall be initiated and performance shall fall within the parameters of 6.2.1.1 (Tank).

6.2.2.5 Blocked Orifice.

One (1) each 20# and 35# cartridge, mated with AMs, shall be blocked in a non-leak manner. The cartridge shall then be initiated while in view of a high speed camera. There shall be no fragmentation or action harmful to the wearer.

6.2.2.6 Water Drop.

Deleted.

6.2.2.7 Salt Fog.

One (1) each 20# and 35# cartridge and one AM unit, not mated, will be subjected to salt fog test by Reliant to MIL-STD-810C, Method 509-1, Procedure 1. The exposure to salt fog shall not deteriously affect the finish, nor the normal operation of the parts.

6.2.2.8 Actuating Mechanism Cycling.

A Lanyard pull fixture will be assembled for the purpose of repetitive activation of the mechanism. A total of 500 lanyard-pulled activations shall be made to prove physical capability of repetitive usage of the AM.

Measurement of pull force shall be recorded at the beginning of the test and at each 100 pull interval.

An increase or decrease in pull force in excess of TBD is not acceptable.

Buoyancy Tests.

The minimum acceptable inflated pressure shall be 1.2 psi and the maximum 3.5 psi.

PHASE III

6.3 ACCEPTANCE TEST PLAN.

6.3.1 Review Shop Travelers.

100% review shall be made for assembly compliance.

6.3.2 Visual Inspection.

100% inspection shall be made of all deliverables, checking measurements, weight, finishes, absence of sharp surfaces, labeling, packaging, serializing.

6.3.3 Leak Test.

Five (5) 20# and two (2) 35# cartridges shall be randomly selected and, without AM, Veeco leak checked. Any leak thus disclosed will be cause for action as in para. 6.3.4.

6.3.4 Performance Verification.

Tank fire ten (10) 20# and five (5) 35# randomly selected cartridges mated with AMs. Performance shall be normal. Any failure will be cause for random selection of a second lot for identical firing. If any failure occurs in the second lot, or if investigation of the failure in the first lot reflects other than a minor condition, the entire production lot of the failed item shall be rejected.

The quantities specified relate to a lot build of 250 combined total units (6%). Smaller lots will require proportionately less than a combination of 6.

SURVEILLANCE PLAN - SPI FOR PFDs

To provide a base for monitoring life expectancy of SPIs, the following is planned:

From the lot comprising USCG deliverables and ISI test specimens, ISI will preserve 20 each of 20# and 35# SPIs. These will be activated on the schedule outlined below, with the unassigned units held in reserve for a TBD test program for the 2nd 5 year period and for reserves.

1st Year	1 each size, each quarter
2nd Year	1 each size, at 6 months and year's end
3rd, 4th, & 5th Years	1 each size, each year

Firings will be into a Tank and time and pressure compared with that obtained in the Design Verification Test series.

Any significant variance from the norm will be reported to USCG.

TEST SERIES RECAPITULATION

SPI for PFDs

Test Para. No.	20# w/AM	20# wo/AM	35# w/AM	35# wo/AM	
6.2.1.1	7		7		
6.2.1.2	8		8		
6.2.1.3	6		6		
6.2.1.4	2		2		
6.2.1.5		1		2	
6.2.2.1	2		2		
6.2.2.2		1		1	
6.2.2.3	1		1		
6.2.2.4		1		1	
6.2.2.5		2		2	
6.2.2.6			1	1	
6.2.2.7	1		1		
6.3.3		5		2	
6.3.4	10		5		
Total Cartridges	37	10	33	9	
	47		42		
Total AMs					70

LETTER REPORT

INFLATION SYSTEMS INTERNATIONAL
25977-1/2 Sand Canyon Road
Canyon Country, CA 91351

Inflation Systems International Purchase Order Number 0702
Reliant Testing Laboratory, Inc. Job Number 81-7505

Nine (9) Solid Propellant Inflators, Part Number 100160-1, Serial Numbers 6 through 9, and Part Number 100160-2, Serial Numbers 1 through 5, were subjected to the following Qualification Tests, performed in accordance with Inflation Systems International Purchase Order Number 0702 and Inflation Systems International QTP-102.

TEST TITLE	(REFERENCE PARAGRAPH) QTP-102
RANDOM VIBRATION	6.2.2.3
SALT FOG	6.2.2.7
HUMIDITY	6.2.2.2
TEMPERATURE CYCLING	6.2.1.5

There was no visual evidence of damage noted to any of the specimens as a result of the Random Vibration, Humidity, and Temperature Cycling Tests.

There was visual evidence of corrosion noted to the specimens as a result of the Salt Fog Test.

Upon completion of testing, all specimens were returned to Inflation Systems International for evaluation and final disposition.

RELIANT TESTING LABORATORY, INC.

Barry G. Beckett
Director, Quality Assurance

RTL A

BGB/km

RELIANT TESTING LABORATORY

16312 SO. MAIN ST., GARDENA CALIF. 90247

Customer	INFLATION SYSTEMS INTERNATIONAL	Job No.	81-7505
Part No.	100160-1, 100160-2	Report No.	81-7505
Spec.	QTP-102	Date	6 July 1981
Para.	6.2.2.3	Amb. Temp.	70° ± 10°F
S/N	6, 1	Photo	Set-Up
		Test Media	------
Specimen	Solid Propellant Inflators	Specimen Temp.	Ambient

TEST TITLE: RANDOM VIBRATION

INPUT AXIS	X		Y		Z
BAND	FREQUENCY (Hz) From	FREQUENCY (Hz) To	LEVEL (g^2/Hz)	SLOPE (dB/Oct.)	TOLERANCE (± dB)
1	5		.005	-	[illegible]
2	5	50	[illegible]	-	[illegible]
3	50	70	.4	-	±3
4	70	100	.4	-	±3
5	100	500	.04	-	±3
6	500	1000	.04	-	±3
7	1000	2000	.04	-	±1.5
8					
G RMS	12		TEST DURATION	30 MINS/AXIS	
ANALYZER FILTER BANDWIDTH					5 Hz

COMMENTS:

SPECIMENS MOUNTED USING NORMAL MOUNTING MEANS.

RESULTS:

NO VISUAL EVIDENCE OF DAMAGE NOTED

RTL 22

Tested By [illegible] Date [illegible] Witness

RTL A

Report Page No. 3

Job No. 81-7505

Part No. Noted

Serial No. Noted

T.P. No. OIP-102

Paragraph No. 6.2.2.3

TEST TITLE RANDOM VIBRATION

CUSTOMER NAME INFLATION SYSTEMS INTERNAT'L

EQUIPMENT LIST

Name	I.D. No.	Cal. Due	Name	I.D. No.	Cal. Due
[illegible]	0119	[illegible]	12-CHANNEL [illegible]	0127	P.T.U.
[illegible]	0115	1 JUN 81	[illegible]	C015	N/A
[illegible]	0164	1 JUN 81	[illegible] AMP	C072	N/A
[illegible]	0165	1 JUN 81	RTL FIXTURE	F002	N/A

29 JUN 81

SPECIMENS MOUNTED USING
NORMAL MOUNTING MEANS.
TEST ITEM SUBJECTED TO 30 MIN.
OF RANDOM VIBRATION IN EACH
OF THE THREE AXIS (X Y & Z).

Specimen Complied YES

Specimen Deviated NO

Notice of Deviation Written NO

Sheet 1 of 2

Tested By [signature] RTL 22

Date 29 JUN 81

Witnessed By RTL A

Date

D-3

TEST TITLE RANDOM VIBRATION	REPORT PAGE NO. 4
CUSTOMER NAME INFLATION SYSTEMS INTERNAT'L	JOB NO. 81-7505
	PART NO. Noted
	SERIAL NO. Noted
	QUANTITY 2

DATE: 29 JUN 81

X - AXIS

1530 BEGIN VIBRATION.

1600 COMPLETE

Y - AXIS

1625 BEGIN VIBRATION

1655 COMPLETE

Z - AXIS

1730 BEGIN VIBRATION

1800 COMPLETE

RESULTS: NO VISUAL EVIDENCE OF DAMAGE NOTED

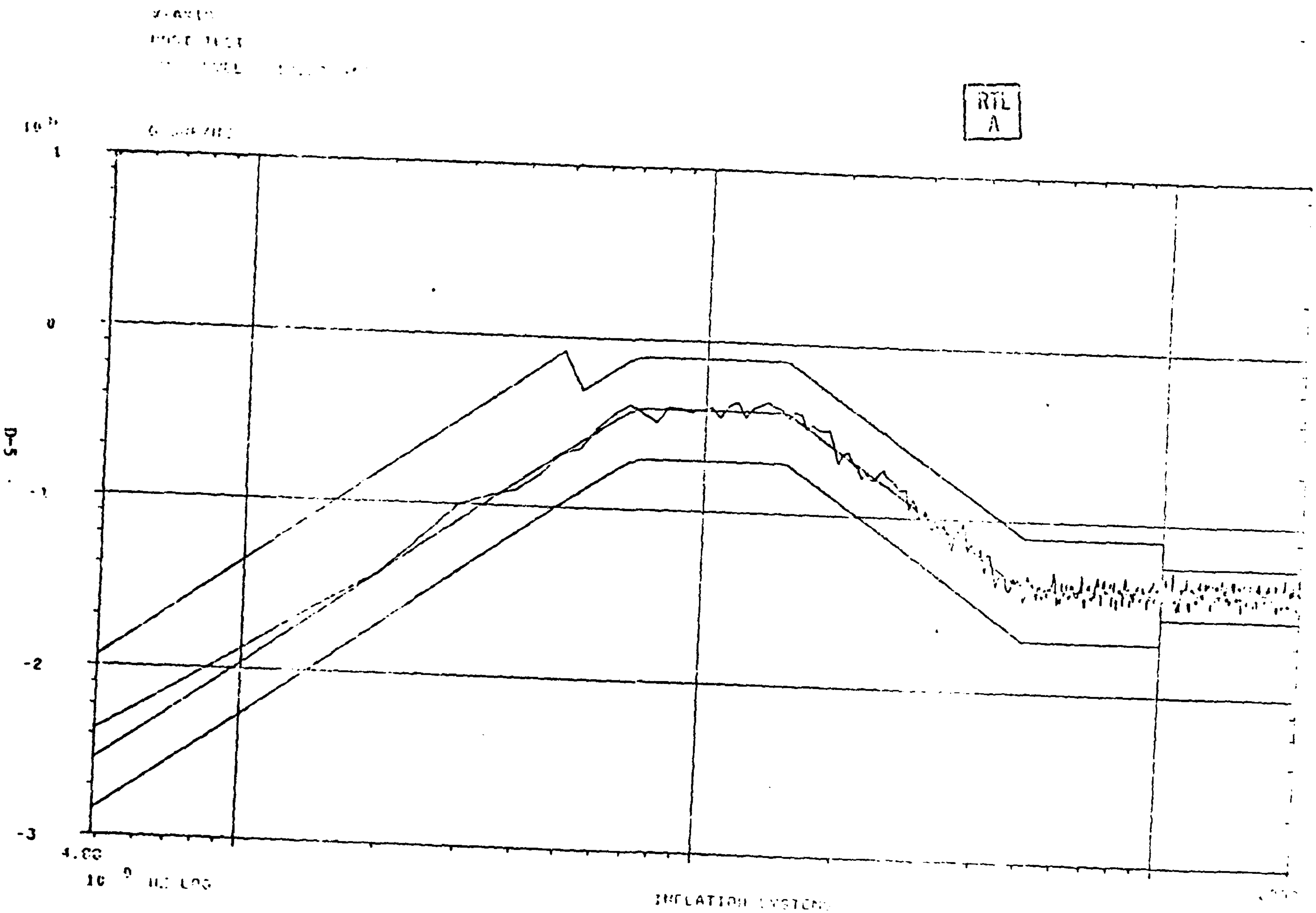
WITNESSED BY: RTL

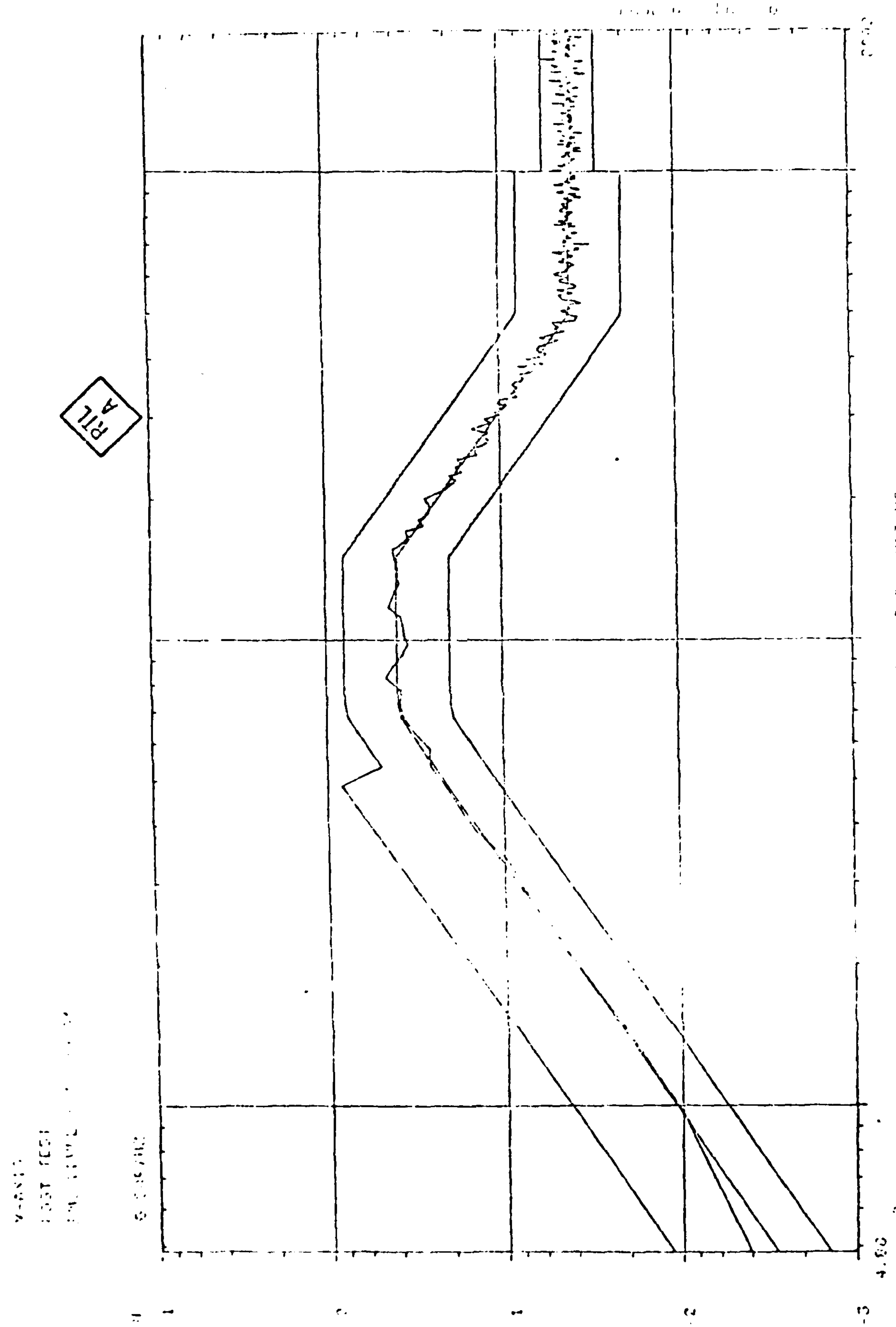
DATE:

TESTED BY: B. Ebana RTL 22

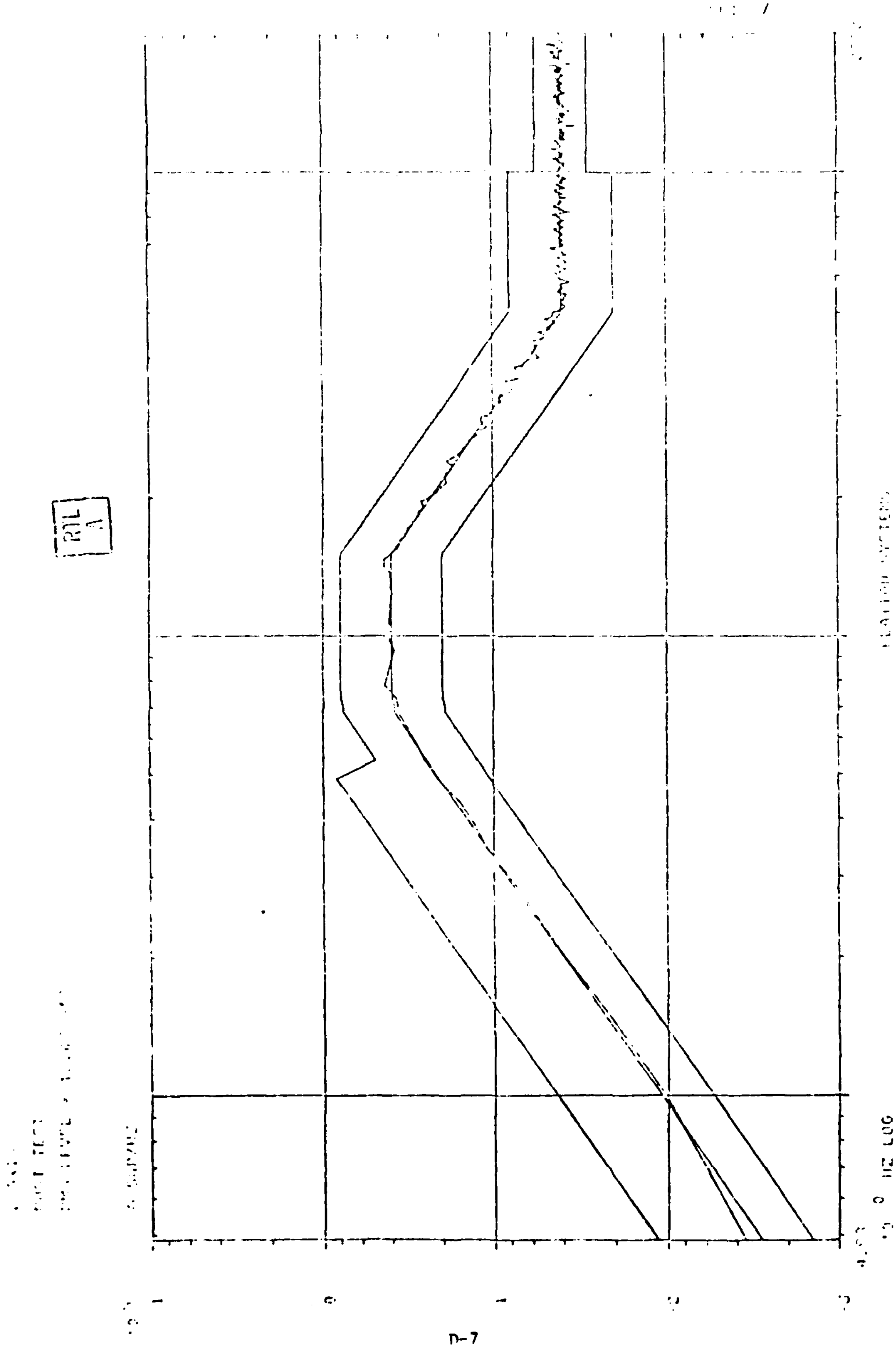
DATE: 29 JUN 81

SHEET 2 OF 2


RTL
A
1
0
-2
-3
4.00



HZ LOG



Report Page No. ___

Job No. 81-7505

Part No. 100160-1, 100160-2

Serial No. 9, 2

T.P. No. OTP-102

Paragraph No. 6.2.2.7

TEST TITLE SALT FOG

CUSTOMER NAME INFLATION SYSTEMS INTERNATIONAL

EQUIPMENT LIST

Name	I.D. No.	Cal. Due	Name	I.D. No.	Cal. Due
Chamber	0200	P.T.U.			
Potentiometer	0707	5 Aug 81			

24 Jun 81

Specimens were installed in the chamber and subjected to salt fog exposure at a temperature of 95°F, 5% salt solution and distilled water. These conditions were maintained for a period of 48 hours.

After 48 hours of exposure, specimens were removed from the chamber and rinsed with warm tap water.

Results: There was visual evidence of corrosion noted.

Specimen Complied See "Results"

Specimen Deviated See "Results"

Notice of Deviation Written NO

Sheet 1 of 1

Tested By Charles Whitlow

Date 24 Jun 81

RTL 24

Witnessed By

Date

Report Page No. 9

Job No. 81 7505

Part No. 100160-1 100160-2

Serial No. 7 3

T.P. No. QIP-102

Paragraph No. 6.2.2.2

TEST TITLE HUMIDITY

CUSTOMER NAME INFLATION SYSTEMS INTERNATIONAL

EQUIPMENT LIST

Name	I.D. No.	Cal. Due	Name	I.D. No.	Cal. Due
Chamber	0201	R.T.U.			
Potentiometer	0707	5 Aug 81			

23 Jun 81

Specimens were placed in the chamber and the temperature was gradually increased to 71°C and a relative humidity of 95% over a period of 2 hours. This condition was then maintained for a period of 6 hours.

Temperature was then reduced to 28°C, 85% relative humidity over a 16 hour period.

The above conditions were repeated for a total of 10 cycles.

Upon completion of testing

Specimen Complied Yes

Specimen Deviated No

Notice of Deviation Written None

Sheet 1 of 2

Tested By Charles White

Date 3 July 81

Witnessed By

Date

TEST TITLE HUMIDITY

CUSTOMER NAME INFLATION SYSTEMS INTERNATIONAL

REPORT PAGE NO. 10

JOB NO. 81-7505

PART NO. 100160-1 & 100160-2

SERIAL NO. 7 3

QUANTITY 2

3 July 81

SPECIMENS WERE REMOVED FROM THE CHAMBER AND VISUALLY INSPECTED.

RESULTS: THERE WAS NO VISUAL EVIDENCE OF DAMAGE NOTED.

WITNESSED BY: RTL A

DATE:

TESTED BY: Charles Whitlow RTL 24

DATE: 3 July 81

SHEET 2 OF 2

RELIANT

B-10

Report Page No. 11

Job No. [illegible]

Part No. [illegible] 1, [illegible]2

Serial No. 8, 4, 5

T.P. No. 91P-102

Paragraph No. 6.2.1.5

TEST TITLE TEMPERATURE CYCLING

CUSTOMER NAME INFLATION SYSTEMS INTERNATIONAL

EQUIPMENT LIST

Name	I.D. No.	Cal. Due	Name	I.D. No.	Cal. Due
Chamber	0243	PTU			
Potentiometer	0202	5 Aug 81			

22 Jun 81

Specimens were placed in the chamber and subjected to a pre-conditioned temperature of -65°F for a period of 30 minutes. After the 30 minute duration, specimens were immediately transferred to a pre-conditioned temperature of +160°F for a period of 30 minutes. The above conditions were then repeated for a total of 25 cycles.

Results: There was no visual evidence of damage noted.

Specimen Complied YES

Specimen Deviated NO

Notice of Deviation Written NONE

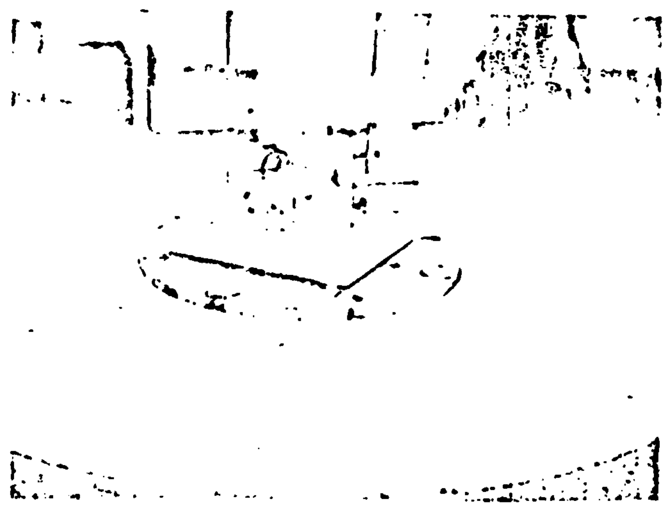
Sheet 1 of 1

Tested By Charles Whitlow

Date 26 June 81

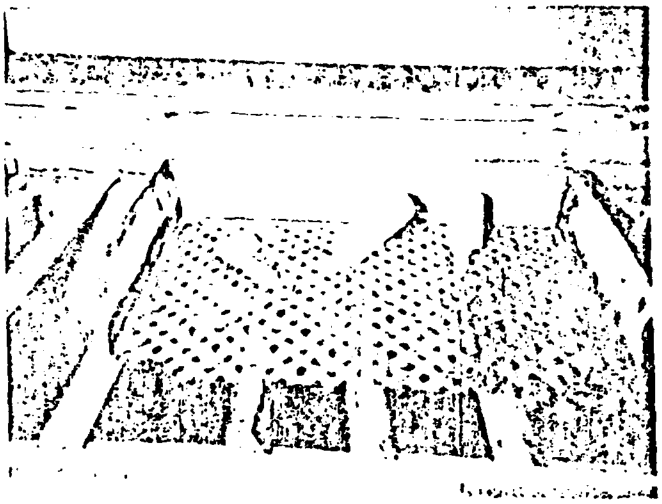
Witnessed By

Date



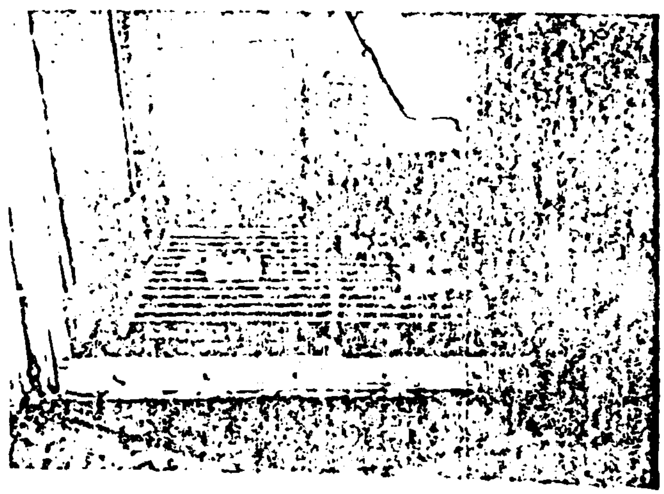
RANDOM VIBRATION

(SET-UP)



SALT FOG

(SET-UP)



TEMPERATURE CYCLING

(SET-UP)